LABORATORY PROBLEMS IN CIVIC BIOLOGY

HUNTER

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CIVIC BIOLOGY

BY

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HUNTER LABORATORY PROBLEMS.

W. P. I

Dedicated

TO MY

PUPILS

WHOSE INTEREST AND ENTHUSIASM HAVE GIVEN RICH SUGGESTION FOR THE CONTENTS OF THIS BOOK

CONTENTS

FOREWORD TO TEACHERS

It has become the fashion in modern pedagogy to teach by the so-called "Problem Method," that is, to attempt to make the child solve problems from the very beginning of his work in the elementary school. But it is one thing to say to the child, "Here is your problem, solve it," and quite another thing to lead him through the several thought processes necessary to the solution of the problem. A child of six may be taught to think, and think clearly, if he is guided so that he makes a generalization after comparison with what his senses tell him he knows. The mistaken notion of our educational system has been that drill and drill alone, pure memory work, is only fitted for the mental life of our young children. Nothing is further from the actual truth. The mental growth of the child is an evolutionary growth, but it is a development based more upon his reaction to the world than upon the mechanism within his body. The nervous system and its connectives develop early. Our education of the nervous system, based on the theory that the nervous system is not well developed, makes simply for the formation of concepts.

Concept forming and concept enlargement are a necessary part in any scheme of education, but the method and the form of straight thinking are of even greater importance. Problems in life are not solved by knowing dates or facts, no matter how important or interesting these may be. The methods of reaching a conclusion, of weighing evidence, of making decisions upon the merits of the facts in a case, of thinking straight from evidence gained from given data, — these are the habits of mind which are worth far more to a child than the actual impact with the subject matter in a textbook. Hence pure science, the handmaiden of clear

thought, needs emphasis placed on method above all else. And the method of science is best found in the laboratory.

Dr. H. E. Walter has well summed up the real use of laboratory work in the following words:

"The laboratory method was such an emancipation from the old-time bookish slavery of pre-laboratory days that we may have been inclined to overdo it and to subject ourselves to a new slavery. It should never be forgotten that the laboratory is simply a means to the end; that the dominant thing should be a consistent chain of ideas which the laboratory may serve to elucidate. When, however, the laboratory assumes the first place and other phases of the course are made explanatory to it, we have taken, in my mind, an attitude fundamentally wrong. The question is, not what *types* may be taken up in the laboratory, to be fitted into the general scheme afterwards, but what *ideas* are most worth while to be worked out and developed in the laboratory, if that happens to be the best way of doing it, or if not, some other way to be adopted with perfect freedom. Too often our course of study of an animal or plant takes the easiest rather than the most illuminating path. What is easier, for instance, particularly with large classes of restless pupils who apparently need to be kept in a condition of uniform occupation, than to kill a supply of animals, preferably as near alike as possible, and set the pupils to work drawing the dead remains? This method is usually supplemented by a series of questions concerning the remains which are sure to keep the pupils busy a while longer, perhaps until the bell strikes, and which usually are so planned as to anticipate any ideas that might naturally crop up in the pupil's mind during the drawing exercise.

"Such an abuse of the laboratory idea is all wrong and should be avoided. The ideal laboratory ought to be a retreat for rainy days; a substitute for out of doors; a clearing house of ideas brought in from the outside. Any course in biology which can be confined within four walls, even if these walls be of a modern, well-equipped laboratory, is in some measure a failure. Living things, to be appreciated and correctly interpreted, must be seen and studied in the open where they will be encountered through-

out life. *The place where an animal or plant is found is just as important a characteristic as its shape or function.* Impossible field excursions with large classes within school hours, which only bring confusion to *inflexible* school programs, are not necessary to accomplish this result. Properly administered, it is without doubt one of our most efficient devices for developing biological ideas, but the laboratory should be kept in its proper relation to the other means at our disposal and never be allowed to degenerate either into a place for vacuous drawing exercises or a biological morgue where dead remains are viewed."

Teaching to think is not a sinecure for the teacher. But by proper use of the laboratory material and the laboratory period, we may make a brave start toward this goal. One preconceived notion of a laboratory period is a time in which the pupil works alone from his specimen in order to interpret something which you and I know is there but of which he is ignorant. The method of Agassiz may be fitted for the graduate university student, but it must be modified for the immature pupil of the high school. We must throw away our college and high school laboratory conception and place ourselves in the laboratory as a *pupil.* Be a leader in a discussion which will center around the specimens in the pupil's hands; present, in connection with the laboratory material, some definite problems relating if possible to some phase of activity of the material in hand, something vital in the mind of the pupil. Lead the discussion (using the printed questions that follow, but augment them with others that will naturally arise during the discussion) toward the solution of some definite phase of the problem in hand. Allow conversation among the pupils; get as many ideas from different pupils as you can; pit the brighter ones against each other and the spirit of competition will incite the dull ones to add their mites. But *guide* the discussion toward a goal, — that is your function as a teacher. Do not be afraid to tell when it is time to give information and do not be afraid to say, "I don't know."

Ultimately the time will come, when the discussion of facts as pupils see them has reached the place where a conclusion may safely be reached. Now is the place for the teacher, again for-

mulating the problem, to give the class — this time as individuals — opportunity to write their generalizations, or their answer to the problem, in the form of a good English sentence or paragraph.

After this is done reading of conclusions by several individuals allows by comparison the fixing of the correct conclusion in the minds of all. Time is thus obtained for rectifying the tangled ideas of those members of the class less able to cope with the problem. Incidentally, this does away to a large extent with correcting laboratory papers, as the student, by comparison with the final corrected conclusion, does his own correcting. This makes for more effective science teaching, as the teacher of science should be a leader, not a drudge.

Sometimes a generalization is asked for, perhaps before the pupil is ready for it, for the object is to incite the worker to be something more than a blind reader of directions and a maker of drawings. An immature conclusion — even a wrong conclusion — in the form of a generalization, is better for the pupil than contentment with no conclusion at all. If the child can be stimulated to think from the very beginning, then do not worry at first over the *exactitude* of his conclusion so long as he is trained in the making of judgments. It is the thought process we are after at first, the *method of thinking* more than the scientifically exact result. The latter will come gradually as the horizon of the pupil widens. We all know our concepts change. What is an exact concept at fourteen would not stand the test at twenty-four or at forty-four. It is a true maxim that experience is the best teacher. Be that so, even experience does not make thinkers of us, unless we know how to profit by her teachings.

The pages that follow are intended to act as a guide and a stimulus to the pupil so that he will be led to see beyond the printed words in the textbook. Many children do not know how to use their text. Diagrams and figures mean nothing to them. The old-fashioned thought questions found in so many textbooks of twenty-five years ago were of great value because they crystallized the problem before the student and focused the attention on the essentials within a given paragraph. The pedagogic value of questions on diagrams is great. The use of graphs is a part

of every educated person's equipment in life. These factors are strongly emphasized in the working out of the problems of this book.

An attempt has been made by the author to be practical as well as logical, and to gain interest through the practical treatment of things that are familiar to the pupil. Whenever possible, technical terms are done away with, and experiments are made as simple as possible without destroying their scientific value.

In general, a few large group problems have been made that directly explain the text of the author's *Civic Biology*, which this manual is intended to interpret in the laboratory. In addition to these, other secondary but closely associated problems are added with less explicit directions, so as to give opportunity for some mental activity in their solution on the part of the pupil. It is not expected that all the problems are to be attempted in a year's course in elementary biology, but a choice should be made by the instructor of what he considers the most important for his own particular classes.

The author wishes especially to thank Messrs. George T. Hastings, John W. Teitz, and Frank M. Wheat of the Department of Biology in the De Witt Clinton High School for their many helpful suggestions and for certain of the exercises and excellent drawings accompanying many of the experiments. All members of the department have in one way or another given ideas to the laboratory exercises which follow, and my sincere personal thanks are due to them as well.

The author also wishes to make acknowledgment to the various sources from which the experiments and laboratory exercises of the following pages were adapted. Of especial value in this respect have been the numerous publications of the Department of Agriculture, the Bureau of Fisheries, and the various health reports of state and city Boards of Health. The Cornell University Reading Course Pamphlets and their *Nature Study Leaflets* have also been of much service, especially in the work on dietetics. In the laboratory study of dietaries the 100 Calorie Portion Table of Irving Fisher, compiled from the *Journal of the American Medical Association*, Vol. XLVIII, No. 16, has also

been useful. For the idea of the biological survey of a neighborhood, I wish to thank Professor Clifton F. Hodge, and his suggestive and inspiring *Nature Study and Life.* William H. Allen has kindly permitted the use of some of his excellent tables compiled in *Civics and Health;* to him I also extend hearty thanks.

The arrangement of the laboratory problems, previously used by Mr. Sharpe and myself in the manual accompanying the *Essentials of Biology,* claims no originality except in application. The laboratory problem form was first worked out, so far as I am aware, by Arthur Stone Dewing in a manual prepared for the Knott Apparatus Company. This book adapts the problem method to young students in an urban community.

The problem questions given at the end of each chapter follow the old and tried plan of summary questions given at the end of a chapter in a textbook for the purpose of bringing together the important points in the mind of the pupil. These questions are so formulated as to make the student use the material worked over in the laboratory, together with the additional information gleaned from the text, so as to reach definite and clear-cut conclusions concerning the essential points in the chapter just finished.

Nearly every laboratory chapter has been prefaced with a few words to the teacher. These are important, as they serve to indicate the viewpoint of the writer and the philosophy underlying the various parts of the book. It is hoped that these suggestions may add clarity and help those who use this book to organize their work.

LABORATORY PROBLEMS IN CIVIC BIOLOGY

I. DIRECTIONS TO THE STUDENT FOR KEEPING NOTES IN BIOLOGY

It is suggested that two notebooks be used. In one, the home notebook, all written notes, either dictation notes or those looked up from original sources, should be placed. The other, a laboratory notebook, should be used for drawings and written work done in class as well as experiments and demonstrations performed in the laboratory. The illustrations on pages 20 and 21 will serve to indicate the appearance of a blank page after laboratory work has been done.

All written work should be in ink, and great care should be exercised not only in the construction of good English sentences, but also in writing. A careless, slovenly page may spoil otherwise excellent work.

Especial care should be exercised in making your drawings. A hard pencil (HHHHH) sharpened to a needlelike point should be used. Do not shade your drawings. Make each line mean something definite. We do not want *artistic sketches* so much as we want *accurate* representations of what you see. Remember a good workman uses good tools; therefore use a sharp pencil, a clean eraser, and an active hand and brain. Drawing without thought of what you are doing is only busy work and does *you* no good.

Among the most important of your laboratory exercises are your experiments. An experiment should have four steps, each of which is separated from each of the others by a paragraph heading.

The four steps are 1, the *problem;* 2, the *method* used; 3, the *observations* made; and 4, the *conclusion* reached.

Jan. 15, 1916. Oxidation Tom Hatch

<u>Problem</u> Do growing seeds give out carbon dioxide?

<u>Method</u>: Take a jar and put some moist sawdust and seeds on the bottom. Stand a small tube of clear lime-water in the bottle and cork; keeping in a warm place so the seeds will start to germinate.

T = Tube of lime water
S = Seeds in saw dust

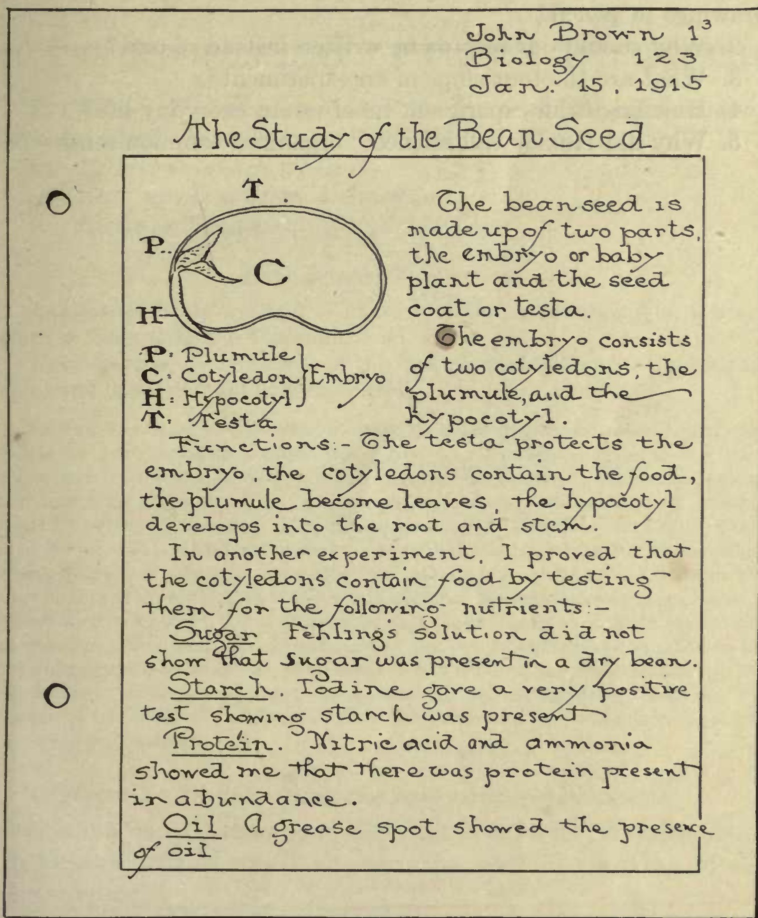
<u>Observation</u>: The seeds start to grow and the limewater gets cloudy.

<u>Conclusion</u>: I know that the only thing that will cause limewater to become milky or cloudy is carbon dioxide, therefore carbon dioxide must have been produced in the bottle by the growing seeds.

<u>Note</u>: The seeds died in a day or two because they used up all the oxygen

Under the heading *problem* you should tell *exactly* what you are trying to solve; your *method* should describe *exactly* how you went to work to set up your experiment and what you subsequently did; the *observations* are what you *saw* (as a result of what you

did); and your *conclusion* should be reached only after weighing the evidence you have obtained in your experiment and then ap-



John Brown 1[3]
Biology 123
Jan. 15, 1915

The Study of the Bean Seed

P: Plumule
C: Cotyledon } Embryo
H: Hypocotyl
T: Testa

The bean seed is made up of two parts, the embryo or baby plant and the seed coat or testa.

The embryo consists of two cotyledons, the plumule, and the hypocotyl.

Functions:- The testa protects the embryo, the cotyledons contain the food, the plumule become leaves, the hypocotyl develops into the root and stem.

In another experiment, I proved that the cotyledons contain food by testing them for the following nutrients:—

Sugar Fehling's solution did not show that sugar was present in a dry bean.

Starch. Iodine gave a very positive test showing starch was present

Protein. Nitric acid and ammonia showed me that there was protein present in abundance.

Oil A grease spot showed the presence of oil

plying it as a definite and *exact* result of an act of thought. An experiment, above all other things, should teach us to think straight; for straight and definite thinking is our greatest asset in later life.

Problem Questions

1. Why should we write laboratory work in ink but make our drawings in pencil?
2. Why should our records be written instead of oral?
3. What are the four steps of an experiment?
4. How might an experiment be of use in everyday life?
5. Why did Huxley call science "organized common sense"?

II. THE ENVIRONMENT OF PLANTS AND ANIMALS

Problem. — *To discover some of the factors of the environment of plants and animals.*

(*a*) *Environment of a plant.*

(*b*) *Environment of an animal.*

(*c*) *Home environment of a girl or boy.*

LABORATORY SUGGESTIONS

Laboratory demonstrations. — Factors of the environment of a living plant or animal in the vivarium.

Home exercise. — The study of the factors making up my own environment and how I can aid in their control.

TO THE TEACHER. — This chapter may be made one of the most vital in the course by introducing in a broad way what the environment gives to the living things which are within it, how plants and animals are limited by their environment, and how man alone of all living creatures may change and modify his environment for better or for worse. This last problem is fundamental to all the work that is to follow. This introductory chapter gives the child the keynote of the problems which follow and enlists his sympathy and interest from the first, for it shows him that biology is a very human subject and one vital to the understanding of how to better his environment. It is understood that the problems as outlined are possible of many modifications, the environment of the pupils serving as the guide to the type of questions to be given. The needs of city children and the condition of their environment differ in many ways from those of country children. But the fundamental factors of the environment are the same, and by comparison should be shown to be the same.

Problem 1: *To determine the factors of environment.*

Method and Observations. — What is a factor in arithmetic? In algebra? How might the term be used in speaking of our surroundings?

NOTE. — The environment of a living thing is that which surrounds it and from which it receives certain materials necessary for its life.

What is your environment? Give examples of some different kinds of environments. (See Hunter's *Civic Biology,* Chap. II.) Explain the term "factors of environment."

Home Work. — Determine the factors of the environment of a plant; of some wild animal; of a cat or a dog (domesticated animals); of yourself. Bring to class a written statement of your answers.

Having compared these different living things in their different environments, decide what factors are common to all environments.

Conclusion. — 1. What are the factors in the environment of living things?

2. Tabulate the factors as suggested below:

	Plant	Animal	Man
Factors of Environment			

Problem 2: *Comparison of a natural with an artificial environment.*

Method and Observations. — Determine what is added to or subtracted from your home environment to make it different from the natural environment of the country. Make two columns. In the first, place the factors of a natural environment. In the second, place the factors of the environment in a city or town.

Natural	Artificial

Remember that the city has various agencies which add to the air certain substances; that housing conditions are changed; that the earth is covered by pavement; and that water supplies and disposal of waste through sewers are artificial factors. Think, too, of many other ways in which the city environment is changed.

Put down all the artificial things that have been added to or subtracted from your home environment to make it different from a natural environment.

Conclusion. — In what respects does a city environment differ from that of the country?

***Problem 3**: To test my home environment.*

Method and Observations. — Using the house score card given below, estimate the condition of your home environment. *This is an exercise for your own use and need not be shown in class unless you so desire.* When in doubt consult your teacher.

House Score Card

Rooms	I	II	III	IV	V	VI	VII	VIII	PERFECT SCORE
Light 10, gloomy 5, dark 0 . . .									10
Well ventilated 15, poorly 7, badly 0									15
Repair: good 5, fair 3, poor 1, bad 0									5
Clean 10, soiled 5, dirty 2, filthy 0									10
One person to room 10, 2 to room 8, 3 to room 4, 4 or more 0 . .									10
Sinks									
Construction: good 5, fair 2, bad 1									5
Water-closet									
Construction: good 3, fair 2, poor 1, bad 0									3
Condition: clean 3, dirty 1, filthy 0									3
1 compartment for 1 family 3, for 2 families 1, for more than 2 families 0									3
Cleanliness									
1 bath tub for 1 apartment 3, for more than 1 apartment 1, no bath 0									3
Personal cleanliness: very clean 7, fairly clean 5, dirty 2, filthy 0									7
Washing									
Stationary tubs 3, removable 2, no tubs 0									3
Cleanliness of clothing: very clean 7, fairly clean 5, dirty 2, filthy 0									7
Meals									
Regular 4, irregular 2, uncertain 0									4
Amount and kind of food: good 4, fair 2, poor 1, bad 0 . . .									4
Cooking: very clean 4, clean 3, dirty 1, filthy 0									4
Refrigeration: good 4, fair 2, poor 1, none 0									4
									100

Definitions of Terms used in House Score Card[1]

ROOMS: *Light* — Light enough to read easily in every part. (In estimating the light, ventilation, and repair of an apartment, divide the sum of the scores of all the rooms by the number of rooms.)

Gloomy — Not light enough to read easily in every part, but enough to see one's way about readily when doors are closed.

Dark — Too dark to see one's way about easily when doors are closed.

Well Ventilated — With window on street or fair-sized yard.

Poorly Ventilated — With window opening on a shallow yard or on a narrow court, open to the sky at the top, or else with 5 × 3 inside window (15 square feet) opening on a well-ventilated room in same apartment.

Badly Ventilated — With no window on the street, or on a yard, or on a court open to the sky, and with no window, or a very small window, opening on an adjoining room.

In Good Repair — No torn wall paper, broken plaster, broken woodwork or flooring, nor badly shrunk or warped floor boards or wainscoting, leaving large cracks.

In Fair Repair — Slightly torn or loose wall paper, slightly broken plaster, warped floor boards and wainscoting.

In Bad Repair — Very badly torn wall paper or broken plaster over a considerable area, or badly broken woodwork or flooring. (Rooms not exactly coinciding with any of the three classes are to be included in the one the description of which comes nearest to the condition.)

SINKS: *Good* — Iron, on iron supports with iron back above to prevent splashing of water on wall surface, in light location, used for one family. Water direct from city water mains or from a *clean* roof tank.

Bad — Surrounded by wood rims with or without metal flushings, space beneath inclosed with wood risers; dark location, used by more than one family; water from dirty roof tank.

Fair — Midway between above two extremes.

WATER-CLOSET: *Good* — Indoor closet. In well-lighted and ventilated location, closet fixture entirely open underneath, abundant water flush.

Fair — Indoor closet, poor condition — badly lighted and ventilated location, fixture inclosed with wood risers, or poor flush.

Poor — Yard closet — separate water-closet in individual compartment in the yard.

Bad — School sink — sewer-connected privy, having one continuous vault beneath the row of individual toilet compartments.

Conclusion. — 1. Is my home environment as good as it should be? 2. How might I improve it?

[1] This and the following are modified from Allen, *Civics and Health*, Ginn and Company.

***Problem 4**: To learn the conditions of my city environment.*

Method and Observations. — Use this score card in a manner similar to that of your last exercise. Judge each item carefully.

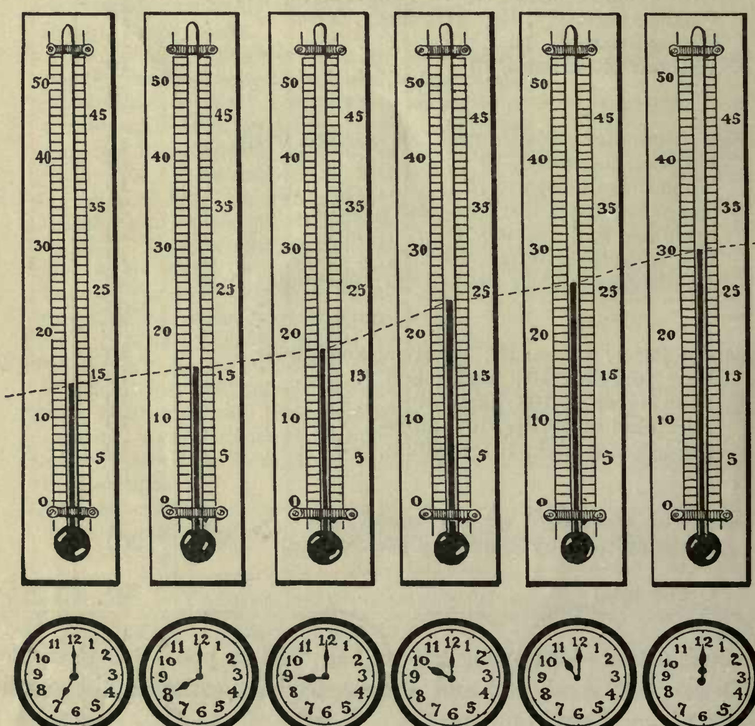
Score Card for Citizens' Use	Perfect	Allow
Schoolhouse: Well ventilated, 20; badly, 0–10 . . .	20	
Cleaned regularly, 20; irregularly, 0–10 . . .	20	
Feather duster prohibited, no dry sweeping, 10 .	10	
Bubble fountains, 10	10	
Has adequate play space, 10; inadequate, 0–5 .	10	
Has clean drinking water, 10	10	
Has clean toilets, 10; unclean, 0–5	10	
Outdoor recreation parks, 10; none, 0	10	
	100	
Church: Well ventilated, 10; badly, 0–5	10	
Heat evenly distributed, 10; unevenly, 0–5 . .	10	
Cleaned regularly, 10; irregularly, 0–5	10	
Without carpets, 10	10	
Without plush seats, 10	10	
	50	
Streets: Sewerage underground, 20; surface, 0–10 .	20	
No pools neglected, 10	10	
No garbage piled up, 10	10	
Swept regularly, 20; irregularly, 0–10	20	
Sprinkled and flushed, 10	10	
Has baskets for refuse, 10	10	
All districts equally cleaned, 20; unequally, 0–10	20	
	100	
Near-by Stores: Clean, 10; poorly cleaned, 0–5 . .	10	
Free from flies, 10; partly, 0–5	10	
Food screened, 10; partly, 0–5	10	
Milk used in bottles, 10; dipped, 0	10	
Grade goods high, 10; medium, 5–0	10	
	50	
Home: Use score card already worked out . . .		
Multiply total by 2, making perfect total . .	200	
Grand total	500	

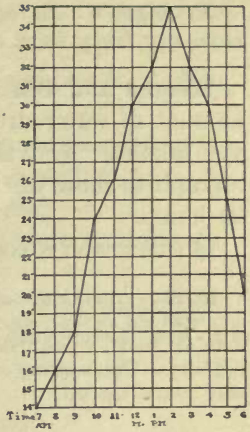
Conclusion. — Allowing 200 as bad, 250 as poor, 300 passable, 350 fair, 400 good, 450 and above excellent, estimate the conditions of your environment.

Problem 5: *To determine and to illustrate by a graph the changes of temperature (one of the factors of the environment) during a given day.*

Materials. — Thermometer, clock, graph paper.

Method and Observations. — Take the temperature (outside) at 7 A.M. and at each successive hour during the day until 6 P.M. On a piece of graph paper lay off a line parallel to the bottom of the page. On this line, at equal distances, place your hours, beginning at 7 and ending at 6. Then from the line made as a base, erect perpendiculars on each of the hour marks. On these perpendiculars mark the record of the thermometer at the given hour. Begin your record at the base line, *e.g.*, if the thermometer

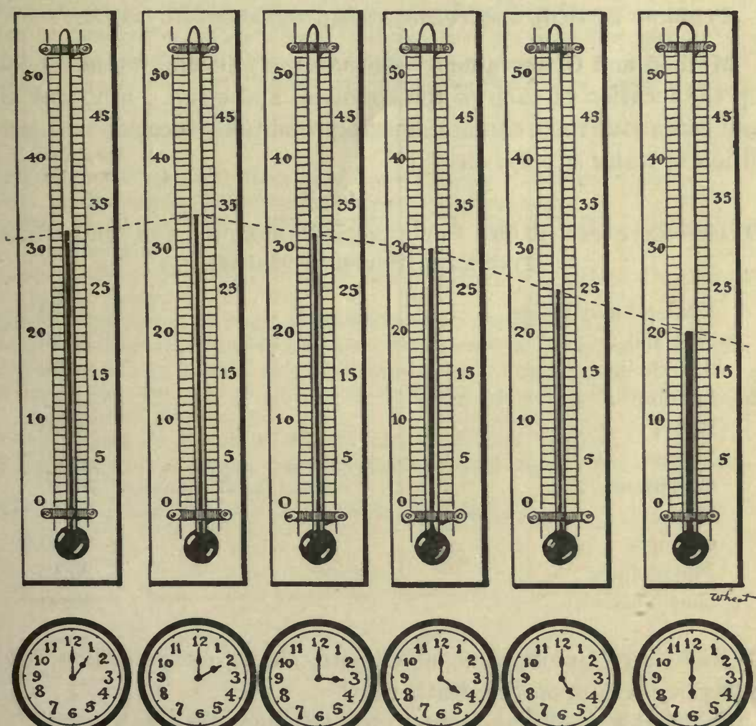




registers 50° at 7 A.M., make 50 your starting point on the line, and if the thermometer has risen to 56° at 8 o'clock, then count off six squares on your graph paper above the base line. Do this for each hour in the 12 for which your record has been made. Connect the marks made on the vertical lines. The result is a curve like the accompanying, showing the temperature record of the day.

Conclusion. — What changes take place in the temperature factor of a given day?

NOTE. — Another suggested exercise is: Relation of the body to intake of water.



***Problem 6**: To make a graph to show how much fluid I take into my body in a day.*

Method and Observations. — Make a careful estimate of the amount of water drunk by glasses or cups and note hours when you take it. Note also milk, coffee, tea, soda, etc., taken. Make a graph to show when and how much fluid passes into the body in 24 hours.

Is this graph a continuous curve? Explain.

NOTE. — Ability to make and to understand graphs is something that every well-educated girl and boy should acquire. The above exercises are suggested as easy data for making two different graphs, each of which will have a different appearance. Teachers are expected to give the class data from which other graphs may be constructed.

***Problem 7**: May environment influence public health?*

Method and Observations. — Study the following table. Look up the location of each of the countries and cities. Find out all you can about their climate, housing conditions, location and condition of water supply, etc.

DEATH RATE PER 10,000 POPULATION, PNEUMONIA AND BRONCHITIS, FIVE-YEAR PERIOD 1896–1900

England and Wales	22.70
Scotland	27.40
Stockholm	26.70
London	31.20
Berlin	16.10
Vienna	39.70
Christiania	21.30
Boston	30.60
Chicago	24.20
Philadelphia	25.10
New York city	36.60

Might any factors, such as climate, slums, overcrowding, etc., have an effect upon the death rate?

Conclusion. — What factors may influence the death rate?

Problem Questions

1. What is meant by environment? Give examples for a plant; a canary; a cat; yourself.
2. How might a given factor of the environment, as the air, be changed in your home? In a factory? In a mine?
3. How might climate affect the environment?
4. Your school is an important part of your environment. What might *you* do to better it?
5. What is a graph? Of what use is a graph? Explain.
6. Why should every well-educated person understand graphs?

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III. THE INTERRELATIONS OF PLANTS AND ANIMALS

Problem. — *To discover the general interrelations of green plants and animals.*

(*a*) *Plants as homes for insects.*
(*b*) *Plants as food for insects.*
(*c*) *Insects as pollinating agents.*

Laboratory Suggestions

A field trip. — Object: to collect common insects and study their general characteristics; to study the food and shelter relations of plants and insects. The pollination of flowers should also be carefully studied so as to give the pupil a general viewpoint as an introduction to the study of biology.

Laboratory exercise. — Examination of simple insect, identification of parts — drawing. Examination and identification of some orders of insects.

Laboratory demonstration. — Life history of monarch and some other butterflies or moths.

Laboratory exercise. — Study of simple flower — emphasis on work of essential organs, drawing.

Laboratory exercise. — Study of mutual adaptations in a given insect and a given flower, *e.g.*, butter and eggs and bumblebee.

Demonstration of examples of insect pollination. — Field work if possible.

To the Teacher. — In a broad way this chapter may be used to show the interdependence of organisms. As much of the work as possible should be made to depend upon field trips, as the interest thus gained carries over into the laboratory later. Specifically, emphasis should be placed on the accurate determination of relations existing between a given insect and flower as in cross pollination. For this purpose careful study should be made of some *one* flower in connection with some one insect that is known to act as a pollinating agent.

To the city child, trips to the parks and fields are especially helpful because they set right his reaction to the term "environment." For that reason especial emphasis is made in this book, a *civic* biology, to field trips. The young citizen should see a reason for the inclusion of vast sums in a city budget for the purchase and maintenance of parks. This trip should *indirectly* give him reasons which later will justify his actions as a taxpayer and a citizen.

Problem 8: A field trip.

Materials. — For collecting purposes an insect net, cigar boxes containing sheets of cork, insect pins, and a cyanide bottle are useful. (CAUTION. Do not smell the cyanide; even the fumes are deadly poison.) See Comstock's *Insect Life* for good directions how to make nets, cyanide bottle, and collecting boxes.

NOTE. — Read these directions *carefully* before beginning work.

Object of trip: The object of this trip is threefold:

1. To find out some of the relations of mutual help existing between plants and animals.
2. To learn to know a few common insects, and to collect them for later study.
3. To have such an enjoyable time that you will wish to go again by yourself.

a. Insects and Flowers

Method and Observations. — Your trip should include fields and waste lots, covered with weeds and trees. Look for six-legged animals (*insects*) on plants. Do they receive any protection from such plants? Shelter? Food? Give examples under each of the above headings. Do you find any insects laying their eggs upon plants? Why do you think they do this?

Follow a bee until it alights on a flower. Try to find out *exactly* what it gets from the flower, and how it does it. Now observe where it goes next. Do bees visit flowers of the same kind in succession?

What are your conclusions regarding the mutual relations between the bee and the flower? Do both receive benefit? Write your answer on paper supplied by your instructor.

Look for other flying insects that are on flowers. Extra credit is given for the working out of the relation between a butterfly and a flower.

Carefully observe the goldenrod blossoms for yellow and black beetles (locust borer) about 1 inch long. Does the beetle get any good from the plant? Might it give the plant anything in return? Write a paragraph on this.

Observe grasshoppers or other insects on stalks of grass. What are they doing there? Do they give any return to the plant? Write a paragraph on this relation.

b. Collections

Method and Observations. — Collect as many different sorts of insects as possible and bring them to your instructor, who will help you name your specimens. You will study these specimens in detail when you return to school, so be careful not to injure them.

Problem 9: How to know an insect.

Materials. — Any living or dead insect, bee, butterfly, or grasshopper preferred. Hand lens.

Method. — Carefully examine any insect.

Observations. — Notice that the body is divided into three regions: the *head;* a middle part, the *thorax;* and a hind part, the *abdomen.* (See Figs., pp. 29, 30, *Civic Biology.*) These parts are further divided into joints (*segments*). Look at the head. Find the feelers (*antennœ*), the large *compound* eyes, and certain movable mouth parts. What do you find attached to the thorax? How many pairs? Look carefully along the sides of the abdomen for very tiny breathing holes (*spiracles*). All insects breathe by a system of air tubes (*tracheœ*) opening along the sides of the body. The characters you have just found should enable you to distinguish an insect from all other animals.

Conclusion. — 1. Write a paragraph telling what structural characters an insect has.

2. Make a drawing of an insect to show all the parts that we have seen above. Label each part.

Problem 10: To learn to recognize insects that frequent flowering plants.

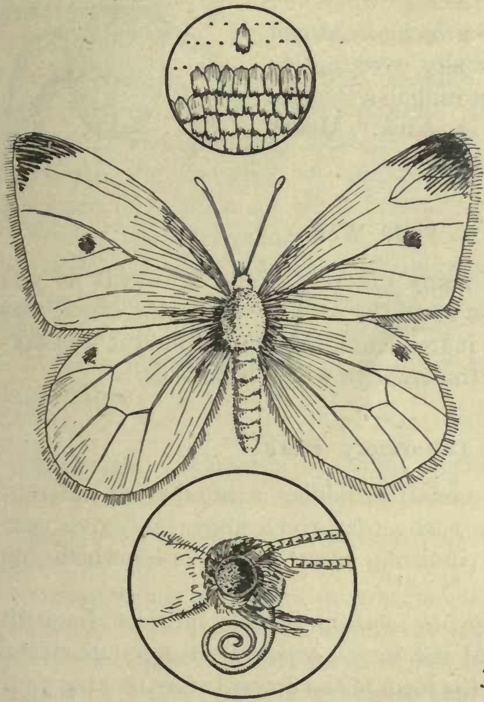
Method. — This work may best be taken on a field trip, although laboratory work from boxes containing mounted insects of different groups may well be substituted.

NOTE. — Insects have been shown to be animals that have three jointed parts to the body, three pairs of jointed legs, feelers, compound eyes, and a more or less hard skeleton on the outside of the body. They may or may not have wings. They breathe through a system of air tubes called *tracheœ.*

The following orders or groups of insects are likely to be found feeding or living upon flowering plants. The position and kind

of wings and the kind of mouth parts are the guides by which we know the *orders* of insects.

Bees and Wasps (*Hymenoptera*, membrane wings). — The wings are gauzy and four in number. These insects have stings (look at the end of the abdomen). The mouth parts are too complicated for a beginner to use for identification.



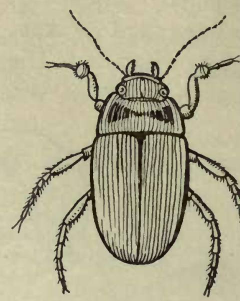
Butterflies and Moths (*Lepidoptera*, scale wings). — Characterized by having two pairs of large wings, covered with tiny bright-colored scales. Head provided with a long proboscis or sucking tube which is coiled up when at rest.

Grasshoppers (*Orthoptera*, straight wings). — Found on most green weeds. The mouth parts are fitted for biting. Hind wings, if present, are folded up lengthwise under the outer wings when at rest.

Flies (*Diptera*, two wings). — Usually small insects with but a single pair of gauzy wings. A short proboscis.

Bugs (*Hemiptera*, half wings). — The wings

are not alone sufficient identification, as they may or may not be present. A jointed proboscis which points backwards is the only sure means of knowing this group.



Beetles (*Coleoptera,* sheath wings). — Characterized by having a strong front pair of wings called *elytra,* usually covering the hind wings and always meeting in a straight line down the middle of the back. Mouth parts hard, pincher-like jaws.

a. Field Work

Method. — Collect as many different kinds of insects as you can, making careful notes as to the locality where the insect was found, the flowers which it frequents, the kind of food it was taking from the flower, and the order to which it belongs.

b. Laboratory Work

Observations. — From boxes containing a number of different insects pick out one from each order given above and give your reasons for placing that particular insect in the order which you have chosen for it.

Conclusion. — 1. Why do certain insects always frequent certain flowers? Look at the insect, especially the mouth parts, very carefully and study the form of the flower before making your decision.

2. How would you pick out (*a*) a bee, (*b*) a butterfly, (*c*) a bug, (*d*) a grasshopper from the above insects?

***Problem 11:** To study the life history (metamorphosis) of an insect.*

NOTE. — Field work may be done at a museum, or questions may be worked out from some of the excellent preparations made by the Kny-Scheerer Company or other of the biological supply houses.

a. Eggs

Method and Observations. — In the field look on the under side of leaves for tiny ovoid structures (*eggs*) of moths and butterflies. The eggs of the cabbage butterfly may be found at almost any time on the under side of cabbage leaves.

Conclusion. — Why are the eggs laid on the *under* side of *certain* leaves?

b. Larva or Caterpillar

Observations. — Note that, besides true jointed legs, the caterpillar has others called *prolegs*. How many true legs are there and where are they located? How many prolegs are there?

Locate the spiracles or breathing holes. Remember where they are located on an adult insect.

Watch the caterpillar when it feeds. What kind of mouth parts does it have? Might it do damage to plants? How?

Conclusion. — 1. Is a caterpillar a worm? (Look in your biology for the characteristics of worms.)

2. How might the larvæ of moths or butterflies be of economic importance?

c. Pupa

Materials. — Cocoons of several species of moths with twigs or other parts attached should be furnished for this exercise.

NOTE. — Moths spin a *cocoon* for themselves at this stage. Butterflies spin no cocoon but form a *chrysalis*.

Observations. — Where do you find the cocoon or chrysalis?

Of what does the cocoon seem to be composed? (The cocoon of the Cecropia is excellent for this purpose.)

In a chrysalis locate by means of the body markings the head, antennæ or feelers, eyes, wings, legs, and spiracles. Are all the parts of an adult present?

Open a cocoon. What do you find inside? How do you explain this?

Conclusion. — Making use of all the knowledge you have gained, write a brief description of the pupal stage of an insect and tell of what use this stage might be to the insect. Remember where you find these stages.

d. Adult or Imago

Method. — Examine carefully an adult butterfly or moth.

Observations. — How many body regions has it? How many legs? Wings? Antennæ?

How does this stage differ from the pupal stage?

NOTE. — All the changes undergone by an animal from the time it leaves the egg to the time it becomes an adult are known as the stages of *metamorphosis* of that animal. If no great changes in form occur, then the animal is said to have an *incomplete* or *direct* metamorphosis. But if changes in form such as we have just seen occur, then the animal is said to pass through a *complete* or *indirect* metamorphosis.

Conclusion. — 1. What insects that you have studied pass through a direct metamorphosis? An indirect metamorphosis?

2. If time permits, drawings might be made to illustrate the life history (metamorphosis) of a moth or a butterfly.

***Problem 12**: To learn the structure and work of the parts of a flower.*

Materials. — Any large flower, as the tulip in the spring, or evening primrose or gladiolus in the fall.

Method. — Carefully examine the parts of a flower.

NOTE. — Flowers are built so that the parts are arranged in circles. In regular flowers the same number of parts (or multiples of these parts) will be found in each circle.

Observations. — How many parts in the outermost circle? These parts are called *sepals*. Collectively they make up the *calyx*. What color have the sepals? In a young flower what seems to be their use?

The next circle of parts is called the *petals*. How many are there? What color do they have? Together they form the *corolla*.

The little knobbed organs are called *stamens;* the stalk is the *filament*, the knob the *anther*. Describe what you find in the anthers. This is the *pollen*. Can you determine how it gets out of the anthers? Use a hand lens.

In the center of the flower is the *pistil*.[1] Describe it. The

[1] If the pistil is made up of a number of separate parts, each part is called a *carpel*.

enlarged part at the base (not always easily seen) is the *ovary;* the stalk is the *style;* the tip, which is sticky, is called the *stigma.* On this sticky surface pollen grains will grow. How might pollen get to the stigma?

Cut a cross section through the *ovary.* Describe what you find inside. These little structures are called *ovules.* Under certain conditions, which we will later discuss, a part of a pollen grain will cause these ovules to grow into seeds. nectary glands – pollen

Fill out a diagram like the accompanying in your notebook.

Part of Flower	Color	Shape	Use
Petal			
Sepal			
Stamen			
Pistil ovary			

Conclusion. — 1. What parts of the flower are *essential* for the production of seeds?

2. What are then the *essential organs* of a flower?

Drawings. — 1. A flower from above. Label all parts.

2. A stamen, showing all parts.

3. A pistil, showing all parts.

Problem 13: *The cross-pollination of flowers.*

Method. — Take a trip to a locality where flowers are abundant and make a preliminary study of the relation of insects to flowers.

Observations. — Notice whether the flowers are being visited by insects.

To what orders do these insects belong?

Do bees visit flowers of one sort in succession, or of different sorts? Make a careful study of this point by following a single bee or other insect. Work this out in the case of a butterfly.

Do insects seem to prefer any one color in flowers to another color? Make careful observations on this point.

Can you discover any means by which the flower might attract an insect? Remember insects can probably smell and taste as

well as see. Might the shape of a flower be of use to an insect? How?

Conclusion. — 1. What do insects get from flowers?

2. What kinds of flowers do they frequent most?

3. What do insects give to flowers?

Problem 14: *To study cross-pollination in butter and eggs.*

NOTE. — In the fall of the year one of the best flowers for study is found in the yellow butter and eggs (*Linaria vulgaris*) found in vacant lots and along roadsides. Any cultivated forms of the toadflax family are useful for this purpose.

Materials. — Butter and eggs or other member of the toadflax family, bumblebees in formalin, needle, hand lens. (Diagrams, p. 39, *Civic Biology*.)

Method. — Study carefully the structure of butter and eggs for any adaptations or fitness in structure: (1) to receive insect visitors; (2) to effect self- or cross-pollination.

Observations. — Note the shape of the flower. Are all its petals and sepals regular (the same size and shape)? Might the shape of the flower offer any place for an insect (as a bee) to light? Try it with a bee. What would happen when the body of the bee rested on the lower lip of the flower? Press down this lower lip and look inside the flower for the stamens and pistil. What is there peculiar about the position of the stamens? Hold the flower in a natural position. Could pollen from the stamens reach the pistil?

Examine with hand lens the sides, back, legs, and head of a bumblebee. What do you find? Now push the body of the bee into an open flower. (Remember that the nectar the bee seeks is held in the spur, or pointed projection, of the flower.) Over what structures would the head and back of the bee rub? If the bee visited another flower of the same sort, what would happen?

Conclusion. — 1. How is the butter and eggs fitted to receive insect visitors?

2. What kind of pollination is most common in butter and eggs? How is it brought about?

3. Explain a second method of pollination in butter and eggs.

4. Make a drawing (diagram) to show how a bee helps to pollinate butter and eggs.

***Problem 15**: Special directions for the study of some fall flowers.* (Extra.)[1]

The Evening Primrose (*Onagra biennis*). — The habitat preferred by this flower is dry fields, roadsides, or waste places. The yellow flowers are found in long, upright, densely crowded clusters. A flower cluster in which the individual flowers have no flower stalks or pedicles, with one main axis to the cluster, is called a *spike.* Notice that young and old flowers and fruits are all on the same cluster. Where are the youngest flowers located in the cluster? Is there any flower at the end of the main stalk? Could you determine in advance the length of the flower cluster? Such a cluster is said to be *indeterminate.* Why? Study a single open flower. Note the calyx and corolla. Are the parts distinct? How many petals do you find? Notice that there are eight stamens and that the stigma is four-parted. Cut the ovary in cross section, and see how many locules (spaces) there are.

When a flower has each circle of parts, as the sepals, petals, stamens, and pistils, made up of a certain number of divisions, or when they appear in multiples of that number, the flower is said to be *symmetrical.* Here we see a very striking example of symmetry in a flower.

The chief attraction to insects is the *nectar*, which is formed in nectar glands at the base inside the slender tubular corolla. Information is given to the insects of the contents by a faint, sweet odor. This flower is not visited by many day-flying insects. Can you determine the names of any that do come by day? At night the flower opens more widely and the scent becomes much

[1] To the Teacher. — If the work on flowers is taken up in the spring, field work should result in the collection of jack-in-the-pulpit, oak, willow, skunk cabbage, grasses, and also many wild flowers which show special adaptations for cross-pollination. In the fall butterfly weed, *Salvia*, turtlehead, and various composites show wonderful adaptation. Original investigation on simple problems of this kind have been found by the writer to be the best means of stimulating certain better prepared students to take an abiding interest in this work. Two or three sample investigations are given here that might be used by the student as a form in making reports on other flowers.

more noticeable. Moths are its chief night visitors. The long proboscis is thrust into the flower and quickly withdrawn, but usually a little pollen is carried off on the *palps* (projections on the sides of the head). This may be left on the next flower visited.

Try to determine what other insects, if any, visit the evening primrose at night.

Draw a single flower split open lengthwise to show the position of the parts, and especially any adaptations to insect pollination. Look for any special means for the prevention of self-pollination. Label all the parts.

Moth Mullein (*Verbascum blattaria*). — The moth mullein is one of the most beautiful weeds, despite the fact that few blossoms are found at any given time. The plant flourishes on dry, waste land, roadsides, and open fields. It was introduced into this country and has since become common here and in Canada.

The flowers are found in a long, loose *raceme*. A raceme is like a spike, except that each flower has its own flower stalk developed. Has this cluster yellow or white flowers? Into how many parts is the calyx divided? The corolla? Is the corolla perfectly regular? Notice the five stamens. Is there anything peculiar about the filaments? Are they all of the same length? In spite of the fact that the flower is called moth mullein, it is not pollinated to any extent by moths. Bees and flies are the chief pollen bearers. Bees which alight on this flower do so for the purpose of collecting pollen. This they usually gather from the short stamens, while they cling to the longer ones. As the bee lights on another flower, the pollen on the under side of the body is transferred to the stigma of this flower.

Draw the flower from above, twice natural size.

Jewelweed (*Impatiens biflora*). — One of the most prevalent of all our brookside flowers is the jewelweed. It well deserves its name, a pendant flaming jewel of orange.

This flower is very irregular in shape. Are the flowers single or in clusters? The sepals as well as the petals are colored. The former are three in number, one of which is sacklike in shape and contracted at one end into a spur. The petals are also three in number. Open the flower. Notice how short the filaments of

the five stamens are. Make a note of their position with relation to the pistil. Would self-pollination be possible in this flower?

If it is possible to study jewelweed out of doors in its native habitat, it will be found that humming birds are the visitors which seem best adapted to cross-pollinate the flower. A careful series of observations by some girl or boy upon the cross-pollination of this flower might add much to our knowledge regarding it.

Jewelweed has the habit of producing (usually in the fall) inconspicuous flowers which never open but which produce seeds capable of germination and growth. Such flowers are said to be *cleistogamous*. In England, where the plant has been introduced, it is found to produce more cleistogamous flowers than showy ones, and the showy ones do not produce seed. There are no humming birds in England, and without this means of pollination, the cleistogamous form prevails.

Make a front-view drawing of the flower of jewelweed twice natural size.

***Problem 16**: To find other pollinating agents besides insects.*

Materials and Method. — Study as many other flowers as possible, using Kny or other charts and books of reference to help in your work. Suggested for this are various types of orchids (described and pictured by Charles Darwin), turtlehead, *Salvia*, and others previously mentioned.

Observations. — Look for any peculiarities of structure that seem to be for purposes of pollination. Explain. If possible, study especially the structure of the flowers of sage, pea or bean, and butterfly weed.

Find out how pollination is accomplished in the corn plant; in the pines and grasses. Reading as well as field work will help here. Are stamens and pis-

Agents of Pollination	Examples
Insects	
Wind	
Water	
Other Agents	

tils ever separated by being on different plants? Give examples. Explain.

Conclusion. — Using a form like that on page 43, tabulate the various ways in which pollination is brought about.

Problem Questions

1. What relation might insects and plants have to each other? Is this relation always a useful one?
2. How could you tell an insect from other animals?
3. How could you tell a bee, butterfly, bug, grasshopper, beetle?
4. What is meant by metamorphosis?
5. Of what use might metamorphosis be to an insect?
6. Which is the most beneficial stage of the metamorphosis of a moth or a butterfly? The most harmful stage? Why?
7. Of what use to a flower are its sepals, petals, stamens, pistil?
8. What parts could a flower do without? Why?
9. What do insects get from flowers? What do they do with what they get?
10. Is pollination *intended* by an insect?
11. What do we mean by an *adaptation?* Illustrate from a flower.
12. What do we mean by a *mutual* adaptation? Illustrate from a flower and an insect.
13. What adaptations are found in flowers to prevent self-pollination? Give examples.
14. What agents other than insects might transfer pollen?
15. Compare with your own environment the environment which you have found animals and plants to have in the park. How are the two environments alike and how do they differ?
16. What constitutes an artificial environment? A natural environment?
17. What are some uses to *you* of a city park? Do not look in your book for an answer.

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IV. THE FUNCTIONS AND COMPOSITION OF LIVING THINGS

Problems. *— To discover the functions of living matter.*
(a) In a living plant.
(b) In a living animal.

Laboratory Suggestions

Laboratory study of a living plant. — Any whole plant may be used; a weed is preferable.

Laboratory demonstration or home study. — The functions of a living animal.

Demonstration. — The growth of pollen tubes.

Laboratory exercise. — The growth of the mature ovary into the fruit, *e.g.*, bean or pea pod.

To the Teacher. — The object of this chapter is first to give the child a preliminary or pre-view of the larger problem outlined in the six following chapters, *i.e.*, plant growth and nutrition. Then the concept of the cell as a unit of structure should be worked out and the very important notion of fertilization in its relation to the development of the plant. Problems 17, 18, 19, and 20 might well follow Chapter II, if the teacher desires, and the problems on fertilization introduced after that of the structure of the flower. Experience has shown the sequence here followed, however, to work out well.

Any simple plant or animal tissue can be used to demonstrate the cell. Epidermal cells may be stripped from the body of the frog or obtained by scraping the inside of one's mouth. The thin skin from an onion stained with tincture of iodine shows well, as do thin cross sections of a young stem, as the bean or pea. One of the best places to study a tissue and the cells of which it is composed is in the leaf of a green water plant, *Elodea*. In this plant the cells are large, and not only their outline, but the movement of the living matter within the cells, may easily be seen, and the parts described in the next problem can be demonstrated.

Problem 17: *The uses of the parts of a plant.*

Materials. — Growing plants, seedlings, and red ink.

Note. — A growing plant has roots, stems, leaves, flowers, and fruits.

Method and Observations. — Locate each part in the specimen before you. If you water a growing plant that is badly wilted,

what happens? What would one use of the roots be? What holds a plant in the ground? In seedlings the roots of which have been placed in red ink note carefully the appearance of root, stem, and leaves. Note that the red fluid extends into the leaves. How did it get there? What is one use of the stem to the plant?

Examine a piece of sugar cane, a stem. Taste it. What does it contain? What might another use of stems be?

Examine leaves which are in a sunny window. How are they placed with reference to the light? Later we will find that green leaves make food for the plant when in the sunlight.

We have seen flowers, and found that in time they form fruits. Fruits in turn hold the seeds which give rise to new plants.

Conclusion. — 1. Write a short composition on the uses of all of its parts to a green plant.

2. Fill in a table like the accompanying.

Part of Plant	Use to Plant	Use to Man
Root		
Stem		
Leaves		
Flower		

Problem 18:* *To study the needs and uses of the parts of a living animal.

Method. — Study your pet cat or dog. Make a list of all the things that your pet requires in order to live. Classify the intake of the pet under the headings, Food, Water, Air, etc.

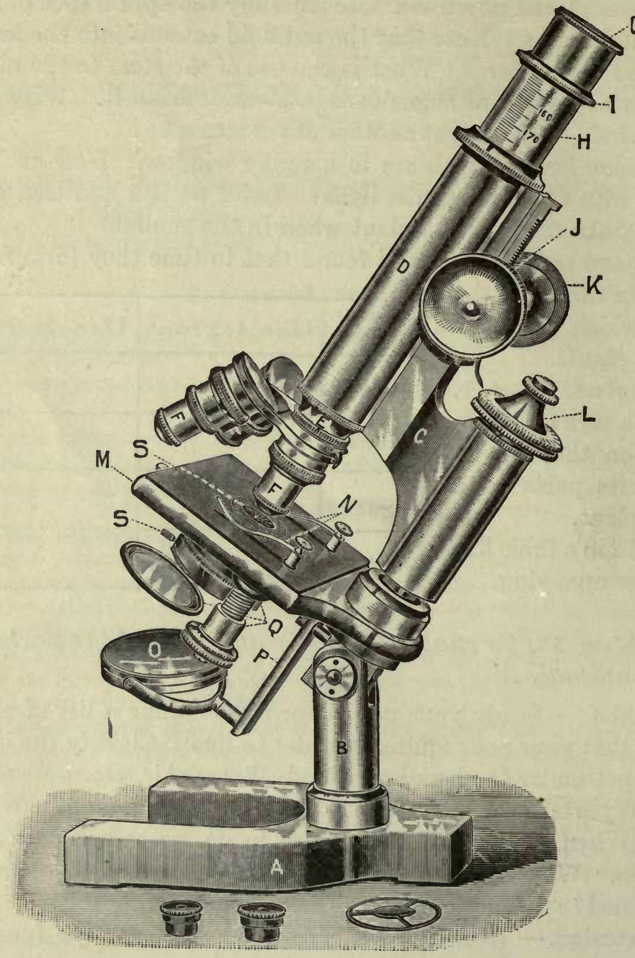
What parts of the body have to do with taking in food? Water? Air? When a structure has a work to do, we call that work its *function*. What other functions has your pet besides those already mentioned? (Your teacher will help you here.)

Conclusion. — What are the needs and what are the functions of a living animal? How do you think they compare with those of a plant?

STUDY OF COMPOUND MICROSCOPE

1. **NOTE.** — The microscope, an instrument for making small objects appear larger, comprises two parts: the stand (A, B, C) and the lenses (F, G).

2. **NOTE.** — The stand consists of the following parts: base (A), pillar (B), stage (M), arm (C), tube (D), diaphragm (S), mirror (O), revolving nose piece (E), the coarse (K) and the fine (L) adjustment.



Of what material is the stand made? What are the advantages of using such material?

3. **NOTE.** — The stand rests upon a broad base or foot.

What is the shape of the base? Why should the base be broad and heavy?

4. **NOTE.** — The jointed, vertical pillar gives attachment to the arm, supporting the main tube of the instrument.

What are the advantages of having the pillar jointed?

5. **NOTE.** — Extending forward from the pillar below the arm is the stage, on which is placed the object to be examined.

Describe the location of the perforation in the stage. What is its use? What is the use of the revolving wheel, or diaphragm, pivoted to the stage?

6. **NOTE.** — Below the stage is a movable bar (P), carrying the mirrors or reflectors.

In how many different directions can you move the mirrors? What is the advantage of having them movable? What kind of surface do the mirrors respectively show? What is the use of the mirrors?

7. **NOTE.** — A hollow cylinder containing two lenses fits into the upper end of the tube. It is called the eyepiece or ocular (G).

Why is the name eyepiece applied?

8. **NOTE.** — Small brass mounts, each containing several lenses, are attached to the tube at its lower end; they are the object lenses or objectives (F, F).

Why is the name objective given to these lenses? How many objectives are there in your microscope?

9. **NOTE.** — The low power (a slightly magnifying objective) has a short and broad mount. The high-power objective has a long and narrow mount.

What fractional numbers do you find on the mount of the high and the low power objectives, respectively?

10. **NOTE.** — The objectives are attached to a revolving device, the nose piece.

What are the advantages of a revolving nose piece?

11. **NOTE.** — To obtain a clear image of the object under examination, we must be able to vary the distance between the lenses and the object; that is, to focus the instrument. The microscope is brought into focus by slightly turning either of the large wheels placed at the top of the arm near the tube.

Why are these wheels called the coarse adjustment? (Turn one of them gently!) What movement results?

12. **NOTE.**— The milled head of the fine adjustment is found at the top of the pillar.

Carefully turn the fine adjustment back and forth. (No more than half a turn in either direction!) Why is this adjustment called "fine"?

Problem 19: To determine the unit of structure in plants and animals.

Materials. — Onion skin, scrapings from mouth, compound microscope, slides, methyl blue.

Method. — Scrape some cells from the inside lining of the cheek with a sterilized knife. Mount in water. Stain with methyl blue. Onion skin may be used and stained with methyl blue or iodine.

NOTE. — A *cell* is a small living structure made up of living matter (*protoplasm*) containing a portion which in part readily absorbs stain. This structure is called the *nucleus*. A cell is usually bounded by a *cell wall* or *cell membrane*.

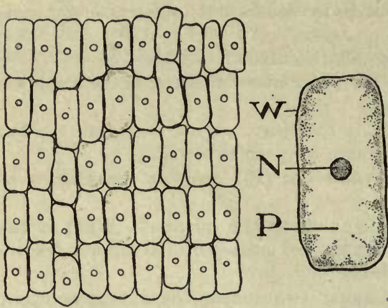


DIAGRAM SHOWING CELLS.
N, nucleus; P, protoplasm; W, walls.

Observations. — What is the shape of a single cell? Are all cells examined the same size? Shape? Can you locate the nucleus (a deeply stained body), cytoplasm (protoplasm outside the nucleus), and cell wall? Any other structures?

Are the cells separate or united with one another?

NOTE. — Cells of the same sort joined together in a plant or an animal form *tissues.* Tissues are grouped in both plants and animals to form *organs,* structures which have some certain work to do, as a leaf, a root, a hand, an eye, etc.

Conclusion. — 1. In the onion do the cells form tissues? Give reason for your answer.

2. What are tissues? Of what are tissues composed?

3. What are organs? Give examples from your own body.

4. Define a cell from what you have seen under the microscope.

5. (Optional.) Draw a few of the cells stained with methyl blue or iodine, showing cell walls, nuclei, and protoplasm.

Problem 20: *To determine some of the properties of protoplasm.*

Materials. — Stamen hairs of spiderwort (*Tradescantia*), leaves of *Elodea*, or the root hairs of radish or grain seedlings are useful. As *Elodea* is easily grown in aquaria, it is recommended for this exercise.

Observations. — Examine a bit of mounted leaf of *Elodea*. What is its general appearance under the low power? Can you locate individual cells in the mass? Note the green bodies in the cells (*chlorophyll bodies*). Can you find the cell walls? The living matter (protoplasm)?

Look closely along the edge of the cells for any movement of living matter within the cell. Does the protoplasm move in any particular direction?

Heat the slide very slightly. What is the result? Cool the slide and note the effect on cell movement.

Conclusion. — 1. In what part of plants may protoplasm be found?

2. Write a paragraph, describing the appearance, movement, and composition of protoplasm in *Elodea*. What are its *reactions* (look up this word in the dictionary) to heat and cold?

***Problem 21**: To study structure and growth of pollen.*

Materials. — Pollen of snapdragon, sweet pea, nasturtium, or tulip; sugar solution (3 per cent, 10 per cent, and 15 per cent), bell jar, sponge, a compound microscope, hand lens.

Method. — Dust some pollen of snapdragon on a glass slide. Examine it with a hand lens. Make a 10 per cent solution of cane sugar and dust some ripe pollen in a drop of the solution placed on a glass slide. Place this slide under a small bell jar with a moist sponge and examine after 24 hours with the low power of the compound microscope. Try sweet pea or nasturtium pollen in a 15 per cent sugar solution, or tulip with a 3 per cent sugar solution.

Observations. — Look for a tubelike structure, the *pollen tube*, growing out of the pollen grains. Describe and sketch one.

Conclusion. — 1. What made the pollen tube grow?

2. Under what other condition have you heard of the growth of pollen?

***Problem 22**: To study the reason for the growth of pollen grains in flowers.*

Method and Observations. — Study the following diagram, the figures, pages 53 and 54, in your *Civic Biology*, and charts for further explanation. Within the pollen tube is a cell known as the *sperm* cell. Note that the cell in the end of the pollen tube is about to unite with the egg. Observe the pathway taken by the pollen tube. How does the sperm cell from the pollen grain get into the ovary? Study the longitudinal section of the ovary. Note a number of ovoid bodies (*ovules*) in the ovary. How could a pollen tube reach an ovule?

1, pollen grain; 2, at time it falls upon stigma; 3, starting to grow; 4, with a pollen tube; *s*, sperm cell nucleus.

NOTE. — If a sperm cell reaches a large cell (called an *egg*) located in the ovule, the sperm and the egg unite to form a single cell. The egg cell is then said to be *fertilized*. This process is known as *fertilization*. After fertilization the egg will grow into a tiny structure known as an *embryo*. The ovule then is known as a *seed*. The embryo within the seed will, under favorable conditions, develop into a young plant.

Conclusion. — 1. What is fertilization and how does it take place?

2. What results from fertilization of the egg of a flower?

3. Why are the stamens and pistils called essential organs?

4. Why is the process of fertilization necessary?

Problem 23: *To discover how fruits are formed.*

a. The Bean

Materials. — Pea or bean flowers, bean pods. Diagram, page 55, *Civic Biology*.

Method and Observations. — Examine an unopened pod. Compare it with the pistil of an old flower. Find the ovary or seed case, the style, and the stigma. Open the pod. Notice the little seeds. How are they attached to the pod? Why are not all the seeds the same size? (Look up the diagram on fertilization.)

Conclusion. — 1. What part of the flower forms the bean fruit?

2. What is one use of a fruit to the plant?

Drawing. — Draw an opened pod showing the seeds. Label all the parts.

b. The Apple

Materials. — Apple blossoms in various stages, or chart. Apples. Diagram, page 56, *Civic Biology*.

Observations. — In an apple blossom how are the sepals placed with reference to the ovary, above or below it? Note the position and appearance of the receptacle, or base, of the flower.

Observe several young apples in different stages of develop-

ment. What parts of the flower appear to grow into the fruit? Cut cross and longitudinal sections of an apple. Find seed cases of the ovary. How many are there? What do you find in them?

Conclusion. — 1. From what does the fleshy part of the apple develop? The part that holds the seeds?

2. Give reasons for your answer in a well written paragraph.

Problem 24: *How and why fruits and seeds are scattered.*

Materials. — Fruits of burdock, jimson weed, clotbur, thistle, beggar's tick, maple, linden, dandelion, crane's-bill, raspberry, acorn, peach, chestnut, pines, and witch-hazel in boxes or glass bottles.

Method. — Collect as many as possible of the above-mentioned fruits and seeds yourself, taking notes on where they were found. Any overgrown city lot will yield some of the above, a trip to a park or to the country in the fall will give you many more. The rest may be obtained from your instructor. After bringing your material to class, place it in boxes provided for that purpose.

Observations. — Classify your fruits and seeds in the following table, giving means of scattering:

Wind Carried	Burrs and Stickers	Explosive	Birds	Man	Water	Other Means

Conclusion. — 1. Write a paragraph telling the *devices* you have found in the seed or fruit to help it be scattered. Also tell all the *ways* in which seeds or fruits may be scattered.

2. Give as good a reason as you are able, why it is desirable for plants to scatter their seeds and fruits at some distance from the parent plants.

Problem Questions

1. What are the needs of living things?
2. What are the functions of living things?

3. Why is reproduction such an important function?
4. What is the difference between pollination and fertilization?
5. What are the parts of a cell? The functions of a cell?
6. What are the characteristics of living matter?
7. What are the properties of living matter?
8. What part of a flower becomes the fruit?
9. Why is it important for plants to scatter their fruits?

Reference Books

Hunter, *Civic Biology*, Chap. IV. American Book Company.
Hunter, *Elements of Biology*, Chap. III. American Book Company.
Hunter, *Essentials of Biology*, Chap. III. American Book Company.
Andrews, *Botany All the Year Round*, pp. 222–236. American Book Company.
Atkinson, *First Studies of Plant Life*, Chaps. XXV–XXVI. Ginn and Company.
Bailey, *Lessons with Plants*, Part III, pp. 131–150. The Macmillan Company.
Bailey, *Plant Breeding*. The Macmillan Company.
Campbell, *Lectures on the Evolution of Plants*. The Macmillan Company.
Coulter, *Plant Studies*, Chap. VII. D. Appleton and Company.
Coulter, Barnes, and Cowles, *A Textbook of Botany*, Part II. American Book Company.
Curtis, *Nature and Development of Plants*. Henry Holt and Company.
Dana, *Plants and Their Children*, pp. 187–255. American Book Company.
Darwin, *Different Forms of Flowers on Plants of the Same Species*. D. Appleton and Company.
Darwin, *Fertilization in the Vegetable Kingdom*, Chaps. I and II. D. Appleton and Company.
Darwin, *Orchids Fertilized by Insects*. D. Appleton and Company.
Ganong, *The Living Plant*, Chap. XI. Henry Holt and Company.
Gray, *Structural Botany*. American Book Company.
Jost, *Lectures on Plant Physiology*. Tr. by R. J. H. Gibson. Frowde, London.
Lubbock, *Flowers, Fruit, and Leaves*, Part I. The Macmillan Company.
Lubbock, *British Wild Flowers*. The Macmillan Company.
Müller, *The Fertilization of Flowers*. The Macmillan Company.
Newell, *A Reader in Botany*, pp. 1–96. Ginn and Company.
Sharpe, *A Laboratory Manual in Biology*. American Book Company.

V. PLANT GROWTH AND NUTRITION. CAUSES OF GROWTH

***Problem.** — What causes a young plant to grow?*

(*a*) *The relation of the young plant to its food supply.*

(*b*) *The outside conditions necessary for germination.*

(*c*) *What the young plant does with its food supply.*

(*d*) *How a plant or animal is able to use its food supply.*

(*e*) *How a plant or animal prepares food to use in various parts of the body.*

Laboratory Suggestions

Laboratory exercise. — Examination of bean in pod. Examination and identification of parts of bean seed.

Laboratory demonstration. — Tests for the nutrients: starch, fats or oils, protein.

Laboratory demonstration. — Proof that such foods exist in bean.

Home work. — Test of various common foods for nutrients. Tabulate results.

Extra home work by selected pupils. — Factors necessary for germination of bean. Demonstration of experiments to class.

Demonstration. — Oxidation of candle in closed jar. Test with limewater for products of oxidation.

Demonstration. — Proof that materials are oxidized within the human body.

Demonstration. — Oxidation takes place in growing seeds. Test for oxidation products. Oxygen necessary for germination.

Laboratory exercise. — Examination of corn on cob, the corn grain, longitudinal sections of corn grain stained with iodine to show that embryo is distinct from food supply.

Demonstration. — Test for grape sugar.

Demonstration. — Grape sugar present in growing corn grain.

Demonstration. — The action of diastase on starch. Conditions necessary for action of diastase.

To the Teacher. — One of the most essential reasons for placing biology early in the school curriculum is due to the fact that as an experimental science it makes for straight thinking. If any one chapter in this book lends itself to logical development, it is the chapter that follows. All laboratory work here outlined builds,

step by step, the general concepts of the necessity for food, for digestion of food, and for the oxidation of food for the release of energy. The food tests are *incidentally* shown, as they should be, in connection with the main problem of food in its relation to the young plant. All tests as tests are subordinated to the main problems as outlined above. Thus the pupil gets his incidental information about certain factors of the environment of the young plant by means of association. Throughout this entire chapter a conscious effort should be made by the teacher to correlate the processes which go on in the young developing plant with the same fundamental processes which go on in the human body. Thus experimental proof lays a foundation for the work in human physiology later.

Problem 25: *To find the relation of the embryo to the food supply.*

Materials. — Dry pods containing beans, soaked beans.

Method and Observations. — Open the pods and pull a bean from its attachment. Note the scar where the bean was attached. This is called the *hilum.*

Look for a tiny hole, the *micropyle,* at one end of the hilum. It was through this hole that the sperm cell reached the egg cell (*micropyle* means "little gate").

Peel off the outer coat (*testa*) of a soaked bean. What use might it have?

Note that the bean separates into two parts, called the *cotyledons.* Take off one cotyledon very carefully, and find two tiny folded leaves, the *plumules,* and a rodlike part, the *hypocotyl.* How does the hypocotyl point with reference to the hilum edge of the bean?

All the parts within the seed coat are collectively known as the *embryo.*

Conclusion. — 1. How is the embryo protected?

2. Can you find a use to the young plant of the hypocotyl? The plumule? The cotyledon?

3. Compare the bean seed with some growing beans (seedlings) a week or two old. How can you answer the questions above?

4. Notice in the older beans the cotyledons seem to be smaller than in the beans that have not sprouted. To account for this let us learn how to test for certain food substances or nutrients, then after making these tests, apply the same tests to the bean cotyledon and draw some valid conclusions as to the use of the cotyledon.

Tests for Organic Nutrients

Problem 26: To test for starch.

Materials. — Cornstarch, iodine solution,[1] and test tube.

Method and Observations. — Add a small bit of starch to a test tube containing a little cold water. Add a few drops of iodine solution. Note the result. Make a little starch paste by heating with water; cool, add iodine as before. Do you get the same result?

NOTE. — The presence of starch and *no other known substance* is shown by a change to a deep blue color on addition of iodine.

Now mash up a little of the bean cotyledon and add iodine. Is there any starch in the bean? Work out in experiment form.

Conclusion. — How would you detect the presence of starch in a substance?

Problem 27: To test for grape sugar.

a. Test with Fehling's Solution

Materials. — Glucose, Fehling's solution,[2] test tubes, Bunsen burner.

Method. — Place in a test tube a little glucose and water, add an equal amount of Fehling's solution. Heat to the boiling point.

Observations. — What color changes take place?

NOTE. — If the color of the mixture becomes brick red upon heating, then grape sugar is present.

Conclusion. — Is grape sugar present in the substance tested?

[1] Iodine solution may be made by adding a few crystals of iodine to enough 95 per cent alcohol to dissolve it well. Or to 1 gram of iodine crystals, add $\frac{2}{3}$ gram of potassium iodide, and dilute to a dark brown color in 35 per cent alcohol.

[2] Fehling's solution may be made as follows: Add 35 g. of copper sulphate to 500 c.c. of water. Solution No. 1.

To 160 g. caustic soda (sodium hydroxide), and 173 g. Rochelle salt, add 500 c.c. of water. Solution No. 2.

For use mix equal parts of solutions 1 and 2. This may also be obtained of druggists, in tablet shape.

b. Test with Benedict's Solution

Materials. — The same as above, but substitute for Fehling's solution Benedict's second solution.[1]

Method. — Place the material to be tested in a test tube with an equal amount of Benedict's solution. Heat to boiling. Continue boiling for two minutes.

Observations. — Are there any changes in color?

NOTE. — If grape sugar is present, a precipitate will be formed having a red, yellow, or green color, depending upon the amount of sugar present.

Conclusion. — 1. Is grape sugar present in the material tested?

2. Test apples, grapes, bananas, pears, or any other fruit to see whether grape sugar is present.

3. Make a table showing the amount of grape sugar present in various foods.

Problem 28: *To test for fats and oils.*

Materials. — Nuts or animal fat, white paper.

Method. — Rub the nut or material to be tested on a piece of paper, and hold to the light, or put material to be tested on a piece of white paper in an oven for a few minutes.

Observations. — What happens to the paper?

Conclusion. — How would you know the presence of oil in a substance?

NOTE. — Ether and benzine extract oils from substances, and on evaporation leave the oil on the container.

Test beans in this manner and write out in problem form for extra credit.

Problem 29: *To test for proteins or nitrogenous foods.*

Materials. — Raw and hard-boiled white of egg, hair, nitric acid, ammonia, test tubes.

[1] Benedict's second solution. — Copper sulphate . . . . 17.3 g.
Sodium citrate . . . . 173.0 g.
Sodium carbonate (anhydrous) . . . 100.0 g.

Make up to 1 liter with distilled water.

With the aid of heat dissolve the sodium salts in about 600 c.c. of water. Pour through filter paper into a glass graduate and make up to 850 c.c. with distilled water.

Dissolve the copper sulphate in about 100 c.c. of water, and make up to 150 c.c. with distilled water. Pour the carbonate citrate solution into a large beaker and add the copper sulphate solution slowly with constant stirring.

After Hawke's *Biochemistry.*

Method. — Place material to be tested in a test tube, with a little strong nitric acid, and heat gently. Note any color that appears. Rinse with water to wash off acid. Add a little ammonia and note any change in color.

Observations. — What change in color takes place when the material is heated with nitric acid?

NOTE. — If a lemon-yellow color appears after the addition of nitric acid followed by a deep orange color on addition of ammonia, there is protein present.

Home Experiments. Method 1. — Put some white of egg in a saucepan and heat it.

Observations. — What happens as the white of egg is heated?

NOTE. — Any substance thickening and becoming white in color is said to *coagulate*, and this indicates the presence of an *albumen* (a protein).

Method 2. — Burn a hair, a feather, or a piece of meat.

Observations. — Note the peculiar odor of burning hair or feather. This shows the presence of a protein.

Conclusion. — 1. What are three ways of knowing the presence of proteins in a given substance?

2. By means of the nitric acid and ammonia test, find out whether there is protein present in the cotyledons of beans. Write up in experimental form.

Tests for Inorganic Nutrients

Problem 30: *To test for the presence of mineral matter.* (Optional.)

Materials. — Meat, tin plate, and flame.

Method. — Heat a piece of meat in a tin plate over a *very hot* fire.

Observations. — Does all the meat disappear? Describe what is left.

NOTE. — The remainder is a tasteless or slightly salty mass of mineral matter.

Conclusion. — How can you determine whether a substance contains mineral matter?

Home Work. — Test beans to see whether there is any mineral matter present, remembering that when heated to a sufficient tem-

perature, all organic material disappears; the remainder is ash or mineral matter.

Problem 31: *To test for the presence of water.*

Materials. — Meat, oven, balance.

Method. — Weigh a piece of meat. Place it in a warm oven until it is thoroughly dry, then reweigh it.

Observations. — What percentage of its original weight does the meat lose?

Conclusion. — 1. What is the cause of most of the loss in weight?

2. As a result of your experiments, write a short statement as to what organic and inorganic nutrients are present in the bean.

3. What happens to the nutrients when the young plant grows? Give *reasons* for your answers.

Problem 32: *To test various food substances for the organic nutrients.* (Home Work.)

Food Tested	Nutrients					
	Starch	Sugar	Fats and Oils	Proteins	Minerals	Water
Potato						
Bread						
Beans						
Egg						
Peanut						
Apple						
Butter						
Test Used						
Use of Nutrient						

Materials. — Pupils may be supplied with testing chemicals to take home or this exercise may well be a laboratory exercise.

Method and Observations. — Test with chemicals, as above, as many different foods as possible, said foods to include meats, cereals, nuts, vegetables, fruits. Make a table like the accompanying. After testing a food for a given nutrient place one of the three fol-

lowing words in the proper column on a line with the food tested: none, little, much. Several pupils may work together and give their results to the class so as to make the record cover as many foods as possible.

Conclusion. — 1. Name five common foods rich in protein; in starch; in grape sugar; in oil; in water.

2. Verify your results by comparing with food charts on pages 278–279 of your *Civic Biology*.

A Study of the Conditions needed to awaken the Embryo in the Seed

Problem 33: To show how much water is needed to make a seed germinate. (Home Experiment.)

Materials. — Soaked peas, sawdust, cups.

Method. — Pupils performing this or any other experiments must remember that the success of an experiment depends upon the accuracy with which it is performed and the exclusion of all factors from the experiment except the one which you are trying to prove. For example, in the following experiment on the effect of different amounts of moisture, all the other factors — temperature, light, food, etc. — must be the same in each of the three cups; the only variable factor being *moisture*. Place an equal amount of moist sawdust in the bottom of each of three cups. Put ten soaked peas in each. Keep the seeds in one cup very wet, those in the second slightly moistened, and those in the third dry. Keep the cups covered in a moderately warm place. Examine them daily for seven days.

Observations. — Tabulate results as follows:

Number of Peas Sprouted

Day	Dry	Moist	Wet
First Day			
Second Day			
etc., to Seven Days			

Conclusion. — What amount of water seems best for germination? Give your reasons.

Problem 34: *To determine the temperature best fitted to cause peas to germinate.* (Home Experiment.)

Materials. — Soaked peas, sawdust, boxes.

Method. — Plant twenty soaked peas in each of three boxes filled with moist sawdust. Put one box where the temperature is about 90° F., another where the temperature is about 70° F., and the third where the temperature is about 40° F. Give all the same conditions of air, light, and moisture. Observe them for ten days.

Observations. — Tabulate the daily observations as follows:

Temperature	DAY									
	1st	2nd	3d	4th	5th	6th	7th	8th	9th	10th
90 degrees										
70 degrees										
40 degrees										

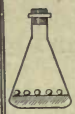
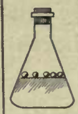
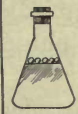
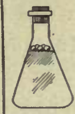
Conclusion. — What temperature seems best for germinating seeds? Reasons.

Problem 35: *To show that seeds need some part of the air in order to grow.*

Materials. — Wide-mouth bottles, sand, soaked peas, corks, paraffin.

Method and Observations. — Fill five flasks with varying amounts of wet sand so that one bottle contains very little air and others are one quarter, half, and three quarters full of air. Put an equal number of soaked peas into each bottle. Cork, and paraffin each cork so as to allow no air to enter. Place where all will have the same conditions of heat and light. Note daily growth on a table like the following.

Conclusion. — In which bottles do the peas grow best? Why?

Number of Peas Sprouted					
1st Day					
2nd "					
3d "					
4th "					
5th "					
6th "					
7th "					
8th "					
9th "					
10th "					

***Problem 36:** To show that food is needed by the embryo in order to grow.*

Materials. — Growing pea and bean seedlings.

Method. — We have already found that beans contain a supply of food for the young plant. Test peas to see if food is also present in the cotyledons. After the peas and beans have begun to germinate remove the cotyledons and place them under favorable conditions for continued growth. What happens? Allow bean seedlings to grow to a height of an inch, then remove both cotyledons from some, one cotyledon from others, and leave others with both cotyledons for controls. Which grow most rapidly?

Conclusion. — What do you conclude from these results?

***Problem 37:** Is any part of the air necessary for combustion?* (Demonstration.)

NOTE. — We have seen that seeds use up food in order to grow and that seeds grow only in the presence of air. We must now study the air in order to find what there is in it that enables seeds to use food and release the energy necessary for growth.

Materials. — Bit of phosphorus, dish, float, bell jar.

Method. — Place a bit of phosphorus on cork and float it in a pan of water. Ignite the phosphorus and quickly invert a bell jar over it.

Observations. — What happens to the phosphorus? What happens to the water in the pan?

NOTE. — Air is composed principally of two elements, nitrogen (about 79 per cent) and oxygen (about 20 per cent). When the phosphorus burns, it unites with one of the elements and forms a substance which dissolves in water. (See p. 20, *Civic Biology*.)

Conclusion. — Judged by the amount of air which is displaced by water, which of the two gases of the air was used up?

Problem 38: To test for oxygen. (Demonstration.)

NOTE. — Certain tests may be made by which the presence of some of the gases which compose the air may be isolated and studied. Pure oxygen, a colorless and odorless gas, is known by its ability to support combustion.

Materials. — Oxone, potassium chlorate, black oxide of manganese, Bunsen flame, test tube with cork and delivery tube, wide-mouth bottle, large dish.

Method. — Heat a little potassium chlorate in a test tube with about the same amount of black oxide of manganese. Chemical action takes place which results in the evolution of oxygen. This may be collected by a delivery tube or used in the test tube. Instead of this method, a patented substance known as oxone may be used. A small piece of oxone placed in water will liberate enough oxygen for several tests. The gas may be collected with the aid of a delivery tube by displacing water from test tubes or bottles.

Observations. — In a test tube containing oxygen plunge the glowing end of a match. What happens to the glowing match? What difference is there between the burning of the match in air and in oxygen?

Place a piece of red-hot iron wire in oxygen; a piece of heated magnesium wire. What happens in each case?

NOTE. — When oxygen combines with any substance, the process is called *oxidation*. The substance with which the oxygen unites is said to be *oxidized*, and heat is released as a result of the process.

When an iron nail is placed in a damp place, it rusts. This is also an oxldation, the iron of the nail uniting with the oxygen of the air.

Conclusion. — 1. Explain exactly what happens when a glowing match is placed in pure oxygen.

2. Is it correct to say that oxygen burns up?

3. What is always released as a result of oxidation?

4. Explain the difference between rapid oxidation (combustion) and slow oxidation.

***Problem 39**: To test for carbon.*

Materials. — Meat, bread, starch, etc., glass plate, candle. Figure page 65, *Civic Biology*.

NOTE. — All organic substances contain the chemical element carbon. This may be proved by burning a substance. If it becomes charred or blackened, it contains carbon.

Method and Observations. — Test meat, bread, dried peas, and starch for carbon.

Hold a clean piece of glass over the flame of a candle. What forms on the glass? Where does it come from?

Conclusion. — Make a table showing substances tested, noting whether or not they contain carbon.

***Problem 40**: To test for carbon dioxide.*

NOTE. — We have seen that substances that burn unite with the oxygen of the air when they are oxidized. Let us next see what happens to the air when carbon unites with oxygen.

Materials. — Candle, limewater,[1] wide-mouth bottle.

Method. — Burn a candle (which has been proved to contain carbon) in a wide-mouth bottle, then add a little limewater and shake the bottle.

Observations. — What change takes place in the limewater?

NOTE. — A gas called *carbcn dioxide* causes limewater to become milky.

Conclusion. — 1. How is carbon dioxide formed?

2. What is the test for the presence of carbon dioxide?

3. Explain this formula, $C + 2\ O = CO_2$.

[1] Limewater is made by adding a piece of quicklime the size of your fist to about 2 quarts of water. Filter before using.

***Problem 41**: To prove that organic substances are oxidized within the human body.*

Materials. — Wide-mouth bottle, glass tube, limewater.

Method and Observations. — Force the breath through a tube into limewater. What happens?

Conclusion. — 1. What is one substance that comes from the lungs?

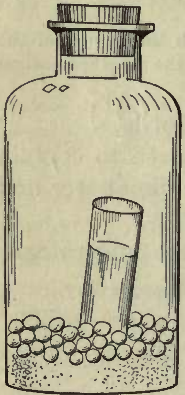
2. How and where must this substance have been formed?

3. If oxidation takes place in the human body, and heat or energy is released as a result of this oxidation, then something must be oxidized within the human body when it does work. Your answer will be helped by reference to the next problem.

4. Burn several different substances as starch, sugar, bread, cake, nuts, and meat in closed jars. Test contents of jars with limewater. What do you conclude was present in these substances? How do you know? What other substance is given off when these materials burn? Touch the jars. What does this suggest with reference to energy released?

***Problem 42**: To prove that growing seeds oxidize food.*

Materials. — Two Erlenmeyer flasks, rubber stopper, soaked peas, blotting paper.



THE INCLOSED BOTTLE CONTAINS LIMEWATER.

Method 1. — Put soaked blotting paper in each of two flasks and place an equal number of peas in each flask. Cork one flask only.

Observations. — Watch for evidences of growth in each flask. Note carefully just what happened to the peas in the closed flask; in the open flask.

Conclusion. — Remembering what you have learned in your previous experiments, how would you account for what you see?

Method 2. — Now test the air in the closed flask with limewater. (Or a bottle containing limewater may be placed in the jar at the beginning of the experiment. See accompanying figure.)

Observations. — What happens?

Conclusion. — 1. How do you account for the presence of carbon dioxide in the closed flask?

2. Why did the seeds in the open flask grow?

3. From what source did the seeds get their energy to grow in the open flask?

General Conclusion. — Write up a brief statement, using proof to show that energy is locked up in food and that it can be released and used only by oxidation.

Problem 43: *To study the fruit of the corn plant.*

Materials. — Ripe corn on the cob.

Method. — Compare the ripe corn on the cob with the picture on page 67 of your *Civic Biology* and with specimens shown by the teacher.

Observations. — What differences are there between the young and the old specimens?

Conclusion. — Is the ear of corn a single fruit or a bunch of fruits? Give reasons for your answer.

Problem 44: *To study the structure of a grain of corn.*

Materials. — Entire soaked corn grains and some cut lengthwise at right angles to the flat surface. Figure page 66, *Civic Biology*.

Method and Observations. — In an entire corn grain find a light-colored area on one side. This marks the position of the *embryo*.

In a grain cut lengthwise at right angles to the flat side find the embryo. Describe its shape, position, and relative size compared with the rest of the corn grain.

NOTE. — The area outside of the embryo is known as the *endosperm*.

Place iodine on the surface of the cut corn grain. Describe what happens. Test for protein.

Conclusion. — 1. What nutrients are present in the corn?

2. Where are they found?

Problem 45: *To find the use of the endosperm of the corn grain.*

Materials. — Sprouted corn grains, scalpel, and sawdust.

Method. — In some corn grains that have sprouted remove the endosperm. Place them side by side in moist sawdust with some normal sprouted grains. Give each lot of seedlings the same conditions of water, light, and air.

Observations. — Watch them carefully for a period of at least two weeks. What differences do you observe in the rates of growth in the two lots of seedlings?

Conclusion. — What is the use of the endosperm to the corn?

Problem 46: *To find whether starch or grape sugar will dissolve in water.*

Materials. — Test tubes, starch, grape sugar.

Method. — Shake up a little starch with water. Let it stand for a few minutes. Shake up an equal amount of dry grape sugar in water. Let it stand for the same length of time as the starch.

Observations. — How do the two compare in appearance?

NOTE. — A substance is said to be *soluble* when it dissolves or entirely disappears from view in water or some other liquid.

Conclusion. — Is starch or grape sugar soluble in water?

Problem 47: *To find how the young plant makes use of the food supply. Digestion.*

Method and Observations. — Wash some dry, unsprouted corn grains and test them for grape sugar. Then cut some corn grains that have just begun to germinate lengthwise through the embryo and test for grape sugar. Look for changes in color between the embryo and endosperm.

NOTE. — Under certain conditions when starch is changed to grape sugar it is said to have been digested. In the corn plant this is accomplished by a digestive ferment, or *enzyme*, called *diastase*.

What differences between the unsprouted and sprouted corn do you find?

Conclusion. — 1. What happens to the starch when corn sprouts?

2. What causes this change?

3. Of what use would this change in the form of the food supply be to the young plant?

4. Why is it necessary that plants digest starchy and other foods?

Problem 48: *What changes take place in starchy foods in the mouth?* (Demonstration.)

Materials. — Cracker, Fehling's solution, Bunsen burner, test tube.

Method and Observations. — Chew an unsweetened cracker slowly. Note any change in taste. Test some of the unchewed cracker with Fehling's solution. Result? Place a little of the chewed cracker and saliva in a test tube, add Fehling's solution, and heat. What happens?

Conclusion. — What happens to starchy foods in the mouth? Of what use might this be to man?

Problem 49: *Conditions necessary for the action of diastase.*

Materials. — Test tubes, diastase, starch paste, ice, Fehling's solution, Bunsen flame, test-tube rack.

Method. — Place a little diastase in three test tubes containing starch paste. Label them 1, 2, and 3. Place 1 in the icebox on the ice; boil the contents of 2 and then place it with 3 in the test-tube rack in the laboratory.

Observations. — After 24 hours test the contents of each of the three tubes for sugar. Has digestion taken place in all tubes?

NOTE. — Diastase has thus been shown to act only under certain conditions. Water must be present and a certain temperature. Its action may be prevented by extreme heat. In these respects it acts as if it were like a living substance.

Conclusion. — What conditions are most favorable to digestion by the diastase?

NOTE. — Pure diastase must be used for this experiment. Most diastase preparations contain grape sugar.

Problem 50: *What is the reason for digestion of starch in the corn grain?*

Materials. — Funnels, filter paper, starch, sugar, beaker.

Method. — Take two funnels, place filter papers within each. In one funnel place a mixture of starch and water, in a second a

solution of grape sugar and water. Collect in a beaker the filtrates (the substances that pass through the filter paper).

Observations. — Do the contents of both funnels pass through the filter papers? Test the contents of the vessels into which the contents of the first and second filter have passed, the first with iodine, the second with Fehling's solution. What happens?

Conclusion. — 1. If the corn seedling absorbs or takes in food, what forms must it be in? How do you know?

2. What is the purpose of digestion in plants?

Problem Questions

1. What results from the fertilization of a flower?
2. What are the uses of the various parts of a plant embryo?
3. How is an embryo protected? (Think of a corn or bean embryo.)
4. What are nutrients?
5. How could you detect starch, protein, grape sugar, or oil in any substance?
6. Why would it be necessary to mash up or boil a substance which you wished to test for starch?
7. How could you detect the presence of mineral matter in a bean?
8. How could you test for the presence of water in a substance?
9. Name five substances containing starch; fat; protein.
10. What conditions are necessary to make an embryo grow?
11. Why is air necessary? Explain just what air does.
12. Could a plant do work without oxygen? Explain.
13. What happens as a result of oxidation of wood or coal?
14. What happens when oxidation takes place in the body?
15. How could you prove that plants and animals use oxygen for the same purpose?
16. What is an ear of corn? A grain of corn? Explain with reference to diagrams in your *Civic Biology*, pages 67, 69.
17. How and where is food stored in a corn grain?
18. A corn grain grows. How can it get its food so as to make use of it?

19. Will starch pass through a filter paper? Will sugar? How can you explain this?

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VI. THE ORGANS OF NUTRITION IN PLANTS — THE SOIL AND ITS RELATION TO THE ROOTS

Problem. — *What a plant takes from the soil and how it gets it.*

(*a*) *What determines the direction of growth of roots?*
(*b*) *How is the root built?*
(*c*) *How does a root absorb water?*
(*d*) *What is in the soil that a root might take out?*
(*e*) *Why is nitrogen necessary, and how is it obtained?*

Laboratory Suggestions

Demonstration. — Roots of bean or pea.

Demonstration or home experiment. — Response of root to gravity and to water. What part of root is most responsive?

Laboratory work. — Root hairs, radish or corn, position on root, gross structure only. Drawing.

Demonstration. — Root hair under compound microscope.

Demonstration. — Apparatus illustrating osmosis.

Demonstration or a home experiment. — Organic matter present in soil.

Demonstration. — Root tubercles of legume.

Demonstration. — Nutrients present in some roots.

To the Teacher. — The principle of osmosis, one of the most difficult concepts the child has to grasp, is the keynote of the work of this chapter. The practical side is seen in the reference to crop rotation, nitrogen-fixing bacteria, and the like. Every educated person should be informed on the principles underlying the work of the bacteria of decay and the nitrogen-fixing bacteria in soils. The root as an organ of absorption should be demonstrated fully, with individual laboratory work on root hairs as structural organs, so that the child may realize the extreme delicacy of these absorbing organs.

Problem 51: *To find out the structure of roots.*

Materials. — Bean, pea, or corn seedlings grown in sawdust.

Method and Observations. — In the roots of a bean seedling notice the main root. From what part of the embryo did this come? Branches of this main, or *primary* root, are called *sec-*

ondary roots. Notice the direction taken by the main root; by the secondary roots; by the rootlets.

Conclusion. — Remembering that a tall stem is sent into the air:

1. What is one reason for the wide spreading of roots?
2. What might be one other use of roots to a plant?

Problem 52: *To determine the influence of gravity on the direction of growth of roots.*

Materials. — Radish or mustard seeds, pocket garden.[1] Diagram page 72, *Civic Biology.*

Method. — Grow radish or mustard seeds in a pocket garden placed on edge until the roots are a half inch long; then turn it on another edge and examine again after 24 hours. Repeat after another 24 hours.

Observations. — Which part of the root grows down each time the garden is turned?

NOTE. — The force which pulls objects toward the center of the earth is known as gravity.

Conclusion. — 1. What causes roots to turn downward?

2. What part of a root is most influenced by this force?

Problem 53: *To find the effect of water on the growth of roots.*

Materials. — Radish or mustard seeds, sponge.

Method. — Plant soaked mustard or radish seeds on the outer side of a moist sponge. Suspend the sponge under a bell jar in moderate temperature.

Observations. — What happens to the roots?

Conclusion. — 1. What effect does water have on the direction of growth of roots?

2. Which influence is more powerful, moisture or gravity?

[1] A pocket garden may be made as follows: Get a couple of 4 × 5 negative plates, clean them, and cut five pieces of blotting paper about ¼ inch smaller than the glasses. Lay the blotters on one of the plates, and cut four ¼-inch strips of wood so as just to fit on the glass outside the blotters. Moisten the blotters, place some well-soaked seeds of mustard, barley, or radish on them, cover the seeds with the other glass, and bind the glasses together with bicycle tape.

***Problem 54**: To study the structure and purpose of root hairs.*

Materials. — Radish or mustard seeds, blotting paper, Syracuse watch glasses, thin glass plates, glass slide, cover slip, microscope. Diagrams pages 74, 75, *Civic Biology*.

Method. — Grow radish or mustard seeds on blue blotting paper in Syracuse watch glasses, covering each watch glass with a thin glass plate.

Observations. — Describe the structures you see growing from the roots. These are called *root hairs*. Where are they the longest? Where the most abundant?

Place a radish or mustard seedling on a glass slide. Mount in a drop of water and cover with a cover slip. Examine with the low power of a microscope.. What can you say of the thickness of their walls? Of how many cells does a root hair seem to consist?

If the root were covered with these thin-walled, delicate structures, what effect would they have upon the absorbing surface of the root?

Conclusion. — 1. Tell what you believe to be the purpose (function) of root hairs. Give good reasons.

2. Why should the wall of a root hair be thin?

Drawing. — A seedling showing position of root hairs.

***Problem 55**: To discover how fluids travel through roots and stems.*

Materials. — Carrot or parsnip, iodine, red ink, scalpel, microscope.

Method. — Cut a cross section through a fleshy root (carrot or parsnip) and dip in iodine. Also place sprouting parsnips in red ink for two or three days, then cut cross and longitudinal sections.

Observations. — In a stained cross section note the *cortex* (outer part) less deeply stained than the *wood* (the inner part).

To the Teacher. — Excellent demonstration material may be obtained by placing celery stems in red ink. Asparagus also shows well. Several different types of stems might be shown to bring out differences in dicotyledonous and monocotyledonous stem structure. Our next experiment will show us how the fluid gets from the outside to the inside of the root.

Find little cores of wood extending out through the cortex into the rootlets. This so-called *central cylinder* is made up of bundles of tubelike cells. The cells collectively form the *fibrovascular bundles.*

In the picture of the cross section (see page 74, *Civic Biology*) find (1) the cortex, (2) the central cylinder, and (3) the root hairs. How many cells are in a root hair? From what part of the root do the root hairs grow?

Place some bean or corn seedlings in red ink. Allow them to remain in the sun for a few hours and then examine the stem and leaves carefully. What has happened?

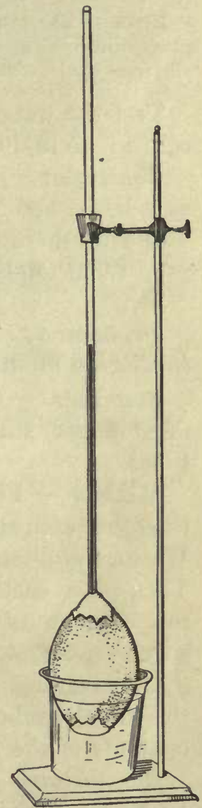
Cut a cross section of one of the above stems. Which part of the root and stem shows the presence of red ink? Examine free-hand sections under the microscope.

Conclusion. — By what path do fluids pass up the root and stem?

Problem 56:* *To find out how root hairs absorb soil water.

Materials. — Egg or glass test tube (large), celloidin, sealing wax, glass tubing, thistle tube.

Method. — To make an artificial root hair we may take either an egg, or a celloidin cell, which is made by pouring a little thin celloidin into a *clean* test tube, revolving the tube rapidly, and then *carefully* removing the film of celloidin which has been formed within the tube. With care a nearly uniform artificial membrane will have been formed within the tube. This, when removed, may be filled with glucose solution, or any dense material that will dissolve in water. Tie the upper end of it tightly over the wide end of a thistle tube and insert the bag in a dish of water.



APPARATUS TO SHOW OSMOSIS.

If an egg is to be used, break the shell at one end and remove

part of it so carefully as not to tear the membrane directly under the shell, then break the other end, insert a glass tube in it, and cement the tube in place with sealing wax. Then place the egg with the exposed membrane in water.

Observations. — Are there any changes in the level of the liquid in the tube?

NOTE. — The process by which two fluids or gases, separated by a membrane, pass through the membrane and mingle is called *osmosis*. The greater flow is usually from the less dense toward the denser medium.

Test the water in the jar (if you used glucose in your artificial cell) to see if glucose passed through the membrane.

Conclusion. — 1. Explain, using one of the above experiments as a basis, how osmosis takes place.

2. How do root hairs take in soil water?

3. What might help force liquids up the stem of the plant?

***Problem 57**: To determine what kind of substances will pass through a membrane.*

Materials. — Glass jar, two thistle tubes, membrane or parchment paper, starch, grape sugar, iodine, Fehling's solution, test tubes.

Method. — Fill two thistle tubes, one with glucose and water, the other with starch and water; tie membranes tightly over each. Wash carefully to remove all starch or sugar from outside of tubes. Then place each in a jar half filled with water. After 24 hours, test contents of the jars, one for starch and the other for grape sugar. (See lower figure, page 100, *Civic Biology*.)

Observations. — Notice if any change has taken place inside the thistle tubes. What changes take place after testing the contents of the jar?

Conclusion. — 1. Does starch or sugar pass through a membrane by osmosis?

2. Can you make a generalization to cover soluble and insoluble substances?

NOTE. — Osmosis or exchange of *gases* will also take place through a membrane. If carbon dioxide and oxygen gases were separated by a membrane, they would tend to pass through the membrane and mingle with each other.

Problem 58: To test organic material in soil.

Materials. — Samples of different kinds of soils, balance and weights, Bunsen burner, pieces of tin.

Method. — Obtain a small quantity of vegetable mold, rich garden soil, and soil from a sandy road. Allow each lot to remain for several days in a dry place so as to remove surplus water. Then take eight ounces of vegetable mold from a forest, eight ounces of rich soil from a garden, and the same amount from a sandy road. Weigh carefully, place each on a piece of tin or sheet iron, and heat red-hot for at least 20 minutes. Now reweigh each sample.

Observations. — Tabulate results as follows:

	Vegetable Mold	Rich Soil	Barren Soil
Original Weight			
Weight after burning			
Loss in Weight			

Conclusion. — 1. How do you account for the losses in weight?
2. Might there be a loss of more than one substance to account for this?

Problem 59: To find what kind of soil holds water best.

Materials. — Gravel, sand, clay, loam, leaf mold, wide-mouth bottles, balance and weights, one-hole rubber stoppers, glass tubing.

Method. — Weigh out an equal amount of gravel, sand, clay, rich loam, leaf mold, and one quarter as much by weight of dry leaves. Prepare six bottles, cut out the bottoms, placing the various materials in the bottles as shown in the lower figure, page 78, *Civic Biology.* Into each bottle now pour slowly one pint of water.

Measure the amount of water that drips through each bottle.

Observations. — Tabulate the exact amount of water left in the soil in each case.

Amount of Water	Gravel	Sand	Clay	Rich Loam	Leaf Mold	Leaves
Added						
Caught						
Left in Soils						

Conclusion. — 1. Of what use is the forest covering of leaf mold?

2. Which kinds of soils would be most favorable for crops and why?

Problem 60:* *What do plants take out of the soil?

Materials. — Glass jars, distilled water, nutrient solution, corn seedlings.

Method. — Partly fill five jars, the first with distilled water, 2 the second with nutrient solution[1] without potassium nitrate, a 3 third with nutrient solution without calcium phosphate, the 4 fourth with nutrient solution without ferric chloride, and a fifth with nutrient solution. Place in the jars corn seedlings with their roots in the liquids. Keep them under observation for two or more weeks.

[1] A nutrient solution known as Sach's solution may be made as follows:

Potassium Nitrate	1.00 gram
Sodium Chloride	0.50 gram
Calcium Sulphate	0.50 gram
Magnesium Sulphate	0.50 gram
Calcium Phosphate	0.50 gram
Ferric Chloride	0.005 gram
Distilled Water	1000.00 grams

Add the ferric chloride at the time the solution is to be used, by adding a drop or so to the solution in the bottle used for the seedlings.

Observations. — In which does the most vigorous growth take place?

Conclusion. — 1. What materials do plants take in with water?

2. What is the source of these materials?

***Problem 61**: How are root hairs able to take mineral matter out of the soil?*

Materials. — Vigorous bean or corn seedling, test tubes on base, phenolphthalein solution.

Method. — To a solution of phenolphthalein add drop by drop a little strong nitric acid. Notice what happens.

Place in another tube containing a phenolphthalein solution (which should be almost neutral) a growing seedling. Leave overnight and then observe. Compare with a control tube containing phenolphthalein.

Observations. — Compare the color in the control tube with the color in the tube containing the seedling.

Compare the tube to which acid was added with that containing the seedling.

Conclusion. — 1. What substance is given off by roots?

2. What effect might this have upon certain minerals in the soil? (Try the effect on a bit of limestone.)

***Problem 62**: What are root tubercles and what is their use?*

Materials. — Clover or bean plants. Diagram page 81, *Civic Biology*.

Method. — Remove and wash carefully the roots of a clover or bean plant. Place in a test tube with a base for laboratory study.

Observations. — Do you find little lumps or tubercles on the roots? Locate exactly.

NOTE. — Root tubercles are small knoblike structures which develop on the roots of *leguminous* plants (clover, alfalfa, peas, beans, cowpeas, etc.). In these tubercles develop millions of little plants called nitrifying bacteria. These plants alone of all others are able to take nitrogen from the air and to combine it with certain mineral substances in the soil to form nitrates. In this form it is taken up by plants.

Conclusion. — 1. By what means do plants get a fresh supply of nitrogen?

2. Why do peas and beans contain so much protein food?

Problem 63: *What is crop rotation and what is its use?*

NOTE. — A regular order of crops in which some nitrogen-fixing crops are followed by plants which take nitrogen from the soil is known as *crop rotation.*

Method. — Suppose on four farms crops are planted each year as follows:

1st Year	2d Year	3d Year	4th Year	5th Year	6th Year
1. Clover	Wheat	Tobacco	Clover	Wheat	Beans and Peas
2. Corn	Rye	Wheat or Oats	Grass	Clover	Wheat
3. Corn	Oats	Wheat	Grass	Potatoes	Corn
4. Clover	Corn	Corn	Clover and Grass	Clover and Grass	Clover and Grass

Conclusion. — 1. Which of the above crops are nitrogen producing? Nitrogen taking?

2. Which of the four farms gets the most out of the soil? Why?

3. Explain what is meant by crop rotation. Why is it of great importance?

Problem 64: *What roots are useful as food?*

Method. — Test as many different roots as possible for the presence of nutrients.

Make a list of some roots used by man as food and some used by animals other than man.

Conclusion. — 1. What roots are most useful to man as food?

2. What roots are used by animals other than man?

Problem Questions

1. Why is the root called the mouth of a plant?

2. From where would water come that roots take in?

3. How could water pass from the root hairs into the woody center of a root?

4. What has osmosis to do with plant nutrition?

5. What has osmosis to do with our own nutrition?

6. How do you know gravity affects roots?

7. Why might forests have an effect upon the climate of a given part of the country?

8. Why is it important not to cut down trees near the sources of our rivers?

9. What do roots have to do with the holding and distribution of water?

10. Why do peas and beans contain a large amount of nitrogenous food?

11. Very much larger yields are had from crops in some parts of the world than in others. How do you account for this?

12. Why do some farmers plant beans or cowpeas in their corn fields between the hills of corn? Is the custom good or bad? Explain.

13. What plants store food in their roots?

14. How do foods become stored in roots?

15. For what reason should a city boy or girl study about roots?

16. Why do farmers plant seeds a short distance below the surface of the ground?

17. Why do farmers cultivate (break up) the soil?

18. What is the reason for placing dead leaves or other dead organic matter on the surface of the ground early in the winter?

19. What is weathering? How does it affect rocks?

20. Find the factors that influence the making of soil.

21. Why should plants not be crowded together in the soil?

22. What kinds of soil retard evaporation? Why?

23. Why do we hear so much nowadays of going back to the soil? What does this term mean?

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VII. PLANT GROWTH AND NUTRITION — PLANTS MAKE FOOD

***Problem.** — Where, when, and how green plants make food.*
(*a*) *How and why is moisture given off from leaves?*
(*b*) *What is the reaction of leaves to light?*
(*c*) *What is made in green leaves in the sunlight?*
(*d*) *What by-products are given off in the above process?*
(*e*) *Other functions of leaves.*

Laboratory Suggestions

Demonstration. — Water given off by plant in sunlight. Loss of weight due to transpiration measured.

Laboratory exercise. —
(*a*) Gross structure of a leaf.
(*b*) Study of stoma and lower epidermis under microscope.
(*c*) Study of cross section to show cells and air spaces.

Demonstration. — Reaction of leaves to light.
Demonstration. — Light necessary to starch making.
Demonstration. — Air necessary to starch making.
Demonstration. — Oxygen a by-product of starch making.

To the Teacher. — In this chapter experimental work may be made to carry almost the entire plan of the chapter. That plants make food out of raw food materials may be demonstrated by a series of logical experiments which leave no doubt as to the steps taken or the factors involved in this wonderful process. That the whole world depends upon the process of photosynthesis is well known. A concept of what the process is and what it does for mankind should be known by every pupil when he has finished the exercises which follow. Laboratory problems having rigid adherence to the logical sequence of events which culminate in food making and food storage in the leaf, will result in increased power on the part of the pupil and a beginning of appreciation of what a developed problem really means. To the critic who would object to so much time given to the processes involved in photosynthesis we would say: starch making and food making may be tied up in a vital manner to the interest of the city child by drawing attention to the economic importance of cereal and other staples furnished man by plants, and by making clear the tremendous importance of green plants in the rôle of food makers on the earth. (See Chapter XI, *Civic Biology*.)

***Problem 65**: To prove that water is given off by a green plant.*

Materials. — Bell jar, a growing single-stemmed green plant as a geranium, rubber tissue, balance.

Method 1. — Cover with rubber tissue a flower pot in which a vigorous rubber plant or geranium is growing, so that only stem and leaves are exposed. Water the plant prior to covering with the rubber tissue. Then weigh the plant. Record weight. Then reweigh the plant after two or three hours.

Observations. — What difference in weight do you observe?

Method 2. — Water the plant, tie up with rubber tissue as before, and place under a bell jar.

Observations. — What collects on the inner surface of the jar?

Conclusion. — 1. To what is the loss of weight due?

2. How and when does the water get out of the plant?

NOTE. — The giving off of water in the form of vapor through the leaves is called *transpiration.*

***Problem 66**: Through which surface of a leaf does transpiration take place?*

Materials. — Two rubber-plant leaves, vaseline, scales.

Method. — Cover the upper surface of one leaf and the lower surface of the other with vaseline. Vaseline both leaf stalks at the end where the leaves were broken off. Balance the leaves exactly on the scales and place in a sunny place.

Observations. — What happens?

Conclusion. — Through which surface of a leaf does transpiration take place? How do you know?

***Problem 67**: To determine how the structure of a leaf fits it for the work it has to do.*

Materials. — Entire leaf.

Method and Observations. — Examine a leaf of maple or oak. Notice that it consists of two parts: a stem, the *petiole*, and a broad expanded part, the *blade*. Note, also, that the petiole leads into a number of branching *veins* which support the blade. Estimate the amount of green leaf surface in a plant in the room by multiplying the surface area of one leaf by the number of leaves on the plant.

Conclusion. — 1. What seems to be one purpose of the veins?

2. Remembering that the veins contain fibrovascular bundles, the tubes which conduct fluids through the plant, determine another function.

3. How is the leaf fitted to receive light? Explain.

***Problem 68**: To study the microscopic structure of a leaf.*

Materials. — Leaf of geranium, glycerine, compound microscope, glass slides, cover glasses, needles. Diagram, page 86, *Civic Biology*.

Method. — Remove with a needle a tiny portion of the under surface of a leaf such as the geranium, or *Tradescantia*, mount in water or glycerine, and examine with the low power of a compound microscope.

Observations. — Note numerous small structures (*stomata*) scattered between the irregular *cells* of the epidermis.

NOTE. — Each *stoma* is bounded by two bean-shaped cells, *guard cells*. By slight changes of shape these control the size of the openings into the leaf.

Study a cross section of a leaf cut through a stoma, or a good chart showing a cross section through a stoma and a vein. Into what do the stomata open? The outer layer of cells, the *epidermis*, has little chlorophyll. What function might these cells have? (Look at the walls.) Beneath the epidermis find a layer of long cylindrical cells, *palisade cells*. Do these contain chlorophyll bodies? Below this layer note a layer of loosely joined cells, the *spongy parenchyma*. Do these cells contain as much chlorophyll as the palisade cells? How are they placed with reference to the stomata? Look at the vein. Where would water pass through it?

Conclusion. — Knowing what you do about the use of a green leaf to the plant, determine one use of the stomata.

Drawings. — 1. Cross section under microscope. Label all parts.

2. Part of lower epidermis showing a stoma.

***Problem 69**: To show the effect of light on green leaves.*

Materials. — Oxalis or nasturtium plants.

Method. — Place oxalis or nasturtium plants near a window.

Observations. — After several days notice the position of the blades of the leaves. Notice also the leaf stalks.

Conclusion. — What is the effect of light on leaves and stems?

NOTE. — Evidently sunlight has something to do with the life of a green plant; for a plant growing in complete darkness is yellow or bleached (for example, sprouting potatoes kept in darkness). Let us see if we can find out by experiment just what is the relation between light and green leaves.

Problem 70: *To determine the relation of light to the presence of starch in a green leaf.*

Materials. — Green plant, black alpaca, alcohol, iodine.

Method. — Place any small green plant in a dark room for 24 hours. Then cover parts of several different leaves with strips of black alpaca. Expose to direct sunlight for an hour or more. Pick off the leaves partly covered with the black cloth, take off the cloth, and place the leaves in hot methyl alcohol. Next wash the leaves and place them in a solution of iodine.

Observations. — What happens to the leaves after placing them in the alcohol? What happens to the leaves placed in iodine solution?

Conclusion. — 1. Why do we place the plant in the dark at the beginning of this experiment?

2. What effect does sunlight have upon green leaves? How do you know?

3. What effect does absence of light have?

NOTE. — Evidently a green leaf under certain conditions (light is one) manufactures starch. Let us find out another.

Problem 71: *Is a part of the air a factor in starch making in leaves?*

Materials. — Green potted plant, vaseline, iodine, alcohol.

Method. — Treat the plant as in the last problem. After removing the plant from the dark room, vaseline both sides of two or three leaves. Place the plant in the direct sunlight for an hour or two, then pick off the vaselined leaves and some others, marking them so that you may know them. Place in hot methyl alcohol. After the chlorophyll is removed, test both vaselined and unvaselined leaves for starch.

Observations. — Do both lots of leaves show the presence of starch?

Conclusion. — What is another factor necessary for the manufacture of starch in green leaves?

Problem 72: *The need of chlorophyll for starch making.*

Materials. — *Coleus* or other plant with variegated leaves, iodine, methyl alcohol.

Method. — Place the plant in full sunlight for an hour or two. Test these several leaves with iodine after removing chlorophyll with methyl alcohol.

Observations. — Do all the leaves show the presence of starch? Do all parts of the variegated leaves show starch?

Conclusion. — Is chlorophyll necessary for starch making?

Problem 73: *To consider the leaf as a manufactory.*

NOTE. — Starch is made of the elements carbon, oxygen, and hydrogen. We have seen that the roots of a plant take up soil water and we have found holes in the leaves through which gases of the air might enter. Water (H_2O) would account for the hydrogen and oxygen, and carbon dioxide (CO_2) will furnish the carbon and oxygen. Let us compare the leaf with a mill for making starch. The sun furnishes the energy to run the mill and the chlorophyll grains are the millstones. Carbon dioxide and soil water are the raw products put into the mill.

Observations. — Study figures on pages 92, 93, *Civic Biology.*

1. What is the source of the water used in the leaf?

2. Where does the carbon dioxide come from? Trace it back to its manufacture.

3. What does the sun have to do with the work of a leaf?

Conclusion. — Write a paragraph telling how starch is made in a leaf. Use the terms machinery, raw materials, manufactured products.

Problem 74: *To show that a gas is given off as a waste product when green plants make starch.*

Materials. — *Elodea,* glass jar, funnel, test tube.

Method and Observations. — Place some *Elodea* under a funnel in fresh water. Then invert a test tube filled with water over the funnel. See that the tube of the funnel is completely filled with

water. Place the jar in the sunlight for a day or two and collect any escaping gas in the test tube. (See figure on page 95, *Civic Biology*.) If carbon dioxide is occasionally passed from a generator through the water in the jar, the evolution of the gas is increased. Place a glowing splinter in the gas. What happens? What does this indicate? Set up the apparatus again and let it stand overnight. Has any gas been formed?

NOTE. — The process of starch formation in green leaves in sunlight is called *photosynthesis* (*photo* — light, and *synthesis* — a building up). Chemically, water (H_2O) and carbon dioxide (CO_2) are built up by the energy of the sun into a substance which ultimately becomes starch ($C_6H_{10}O_5$). During this process oxygen gas is given off as a by-product.

Conclusion. — 1. If work is done by the plant, then how does it use oxygen?

2. What gas would a green plant give off at night? Explain.

3. What gas would be given off in the sunlight?

Problem Questions

1. What substances are given off by green leaves?

2. Trace the pathway of water in a dicotyledonous plant from the time it enters to the time it leaves the plant.

3. What does a plant do with the water it takes in? The gases of the air that enter the leaves? The mineral matter that passes in through the roots?

4. If dead plants are burned in the fall, does as much raw food material get back in the soil as if the dead bodies were plowed under?

5. Why are green plants said to be constructive while animals are said to be destructive?

6. Compare a leaf to a factory. Where does the energy to run the plant come from?

7. Why should the leaves of plants in our homes be frequently dusted and washed?

8. Why do the leaves of lettuce or cabbage when "headed" turn white?

9. What are some adaptations in leaves to receive light?

10. Find some ways in which leaves are protected.

11. Fill out, with the help of your teacher, a table like the following as a summary of the functions of leaves:

	Taken in	Given out	Conditions under which process takes place	Finished Product
Respiration				
Transpiration				
Photosynthesis				
Protein making				

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VIII. PLANT GROWTH AND NUTRITION — THE CIRCULATION AND FINAL USES OF FOOD BY PLANTS

Problem. — *How green plants store and use the food they make.*

(*a*) *What are the organs of circulation?*
(*b*) *How and where does food circulate?*
(*c*) *How does the plant assimilate its food?*

Laboratory Suggestions

Laboratory exercise. — The structure (cross section) of a woody stem.

Demonstration. — To show that food passes downward in the bark.

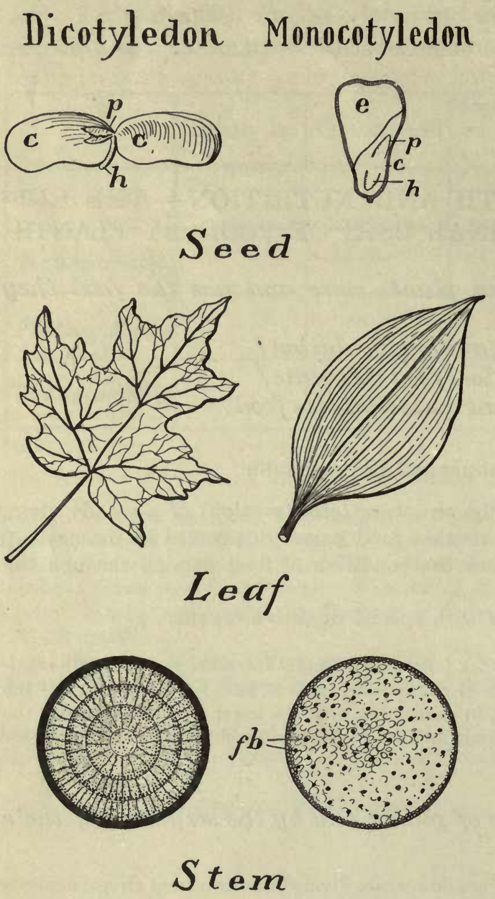
Demonstration. — To show the condition of food passing through the stem.

Demonstration. — Plants with special digestive organs.

To the Teacher. — The work following is simply intended to develop the concept that the stem is an organ of circulation; that it puts the upper part of the plant, the food-making organs, in connection with the lower part of the plant, the organs which absorb raw materials for food making and which act as a storage for manufactured food.

Problem 75: Groups of plants told by the structure of their stems.

Note. — Plants which produce flowers are divided into two great groups depending on whether they have one or two cotyledons in the seed, *i.e.*, monocotyledons and dicotyledons. A bean is an example of the latter, a corn plant of the former. Certain marked differences in the leaves or stems also appear, the dicotyledon usually has veins forming a network while those of the monocotyledon usually run parallel to each other. A third difference is seen in the stem. In the dicotyledon growth takes place from just under the bark and we have annual rings of growth which tell us approximately the age of the stem. In a monocotyledon (for example a cornstalk) the main bulk of the stalk is made up of pith, while scattered through the pith are numerous stringy, tough structures. These are *fibrovascular bundles*. The outside of the corn stem is formed of large numbers of these bundles, which, closely packed together, form an outer *rind*. Thus the woody material gives mechanical support to an otherwise spongy stem.



c, cotyledon; e, endosperm; h, hypocotyl; p, plumule; fb, fibrovascular bundles.

Observations. — Compare stems of a dicotyledon (apple) and a monocotyledon (corn); also, leaves of dicotyledons, oak, elm, or chestnut with those of monocotyledons, lily, grass, or corn.

Conclusion. — 1. Make table comparing differences of (1) stems, (2) leaves, (3) seeds. Note the difference in position in the stem of pith and bundles. (Use lens.)

2. Where is the woody part in a dicotyledon? Where in a monocotyledon?

Problem 76: To study the structure of a woody stem.

Materials. — Small cross sections of apple, horse chestnut, or any other woody stem. Page 98, *Civic Biology.*

Observations. — In a cross section of apple or any other woody twig note: 1. The central soft part, the *pith.* 2. The *wood.* 3. The *bark.* Can you find radiating lines, *medullary rays,* in the wood? How many layers of bark do you see?

NOTE. — Between the wood and the bark is a rapidly growing layer called the *cambium.*

Conclusion. — 1. Judged from the texture, what might be the use to the plant of the outer layer of the bark?

2. Judged from the color, what might be the use of the middle layer?

NOTE. — The inner layer of bark is known as the *bast*. It consists of tubelike cells which carry food from the leaves toward the roots.

3. What are all the uses of the bark?

Drawing. — Make a cross section of a woody stem, labeling all the parts.

Home Work. — Take two potatoes of equal weight. Peel one, leave the other unpeeled. Place the peeled potato (with peelings) on one pan of a balance, the unpeeled potato on the other. Allow these to remain on the balance for several days. What changes do you note? Remembering that the potato is an underground stem, determine another function of the bark. (See page 99, *Civic Biology*.)

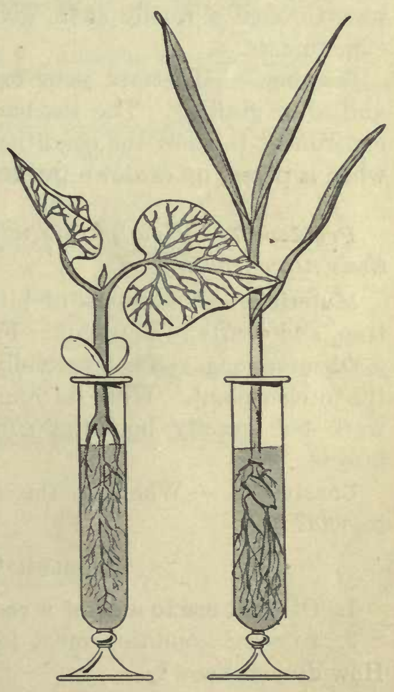
***Problem 77**: To prove that liquids rise through stems.* (Review.)

Materials. — Growing pea or bean seedling, red ink.

Method. — Place the roots of a growing plant in a weak solution of eosin or red ink. Leave a few hours in a sunny place.

Observations. — Notice the stems and leaves of the young plants, particularly the veins in the leaves. Copy the accompanying figures in your notebook and color them to show where fluids rise.

Conclusion. — Through what part of the stem and leaves do liquids rise?



Problem 78: *To find out through which part of a woody stem food passes down.*

Materials. — Growing willow twigs, nutrient solution, or water. Upper figure page 100, *Civic Biology*.

N. B. — This experiment should be started at least three weeks before it is to be used.

Method. — Allow willow twigs to grow in water until they have formed roots, then girdle them by removing a strip of bark about half an inch wide and about an inch above the cut end of the twig. Replace the twigs in water.

Observations. — After several days notice what has happened both above and below the girdled area.

Conclusion. — 1. Through which part of the stem does food get to the roots? How do you know?

2. Write a paragraph telling how water rises and food materials pass through a woody stem, giving reasons from this and other experiments.

Drawing. — Illustrate your experiment with drawings before and after girdling. The teacher should at this point recall the experiment to show the condition of the food in the stem or root when it passes up or down through the fibrovascular bundles.

Problem 79: *How plants with special digestive organs get their nitrogenous food.*

Materials. — Specimens of pitcher plant, sundew, Venus's-flytrap, and charts to illustrate. Figures page 102, *Civic Biology*.

Observations. — Look carefully within the pitcherlike leaves of the pitcher plant. What do you find? With the aid of the chart work out exactly how the sundew and Venus's-flytrap catch insects.

Conclusion. — What do the above plants do with the dead insects?

Problem Questions

1. Of what use to a plant is each part of a woody stem?

2. In what condition must food be to pass through a stem? How do you know?

3. In what condition must food be in order to be *stored* in the cells of a plant? Explain.

4. Mention some stems in which food is stored. From where must this food have come?

5. What is the cambium layer and what is its use to a plant?

6. Look up a reference textbook to find out how water and food pass up and down a monocotyledonous stem.

7. Read a textbook to find out how a dicotyledonous stem grows. How a monocotyledonous stem grows.

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IX. OUR FORESTS, THEIR USES AND THE NECESSITY FOR THEIR PROTECTION

***Problem.** — Man's relations to forests.*

(*a*) *What is the value of forests to man?*

(*b*) *What can man do to prevent forest destruction?*

Laboratory Suggestions

Demonstration of some uses of wood. — Optional exercise on structure of wood. Method of cutting determined by examination. Home work on study of furniture, trim, etc.

Visit to Museum to study some economic uses of wood.

Visit to Museum or field trip to learn some common trees.

To the Teacher. — The practical value of work on forestry is unquestioned. Every pupil of high school age should have not only some knowledge of our forests and their uses, but also a little first-hand experience in recognition of some common trees: their habitat and their use. The methods of cutting lumber and trim also gives a practical side which is of interest to pupils.

***Problem 80:** To determine how lumber is cut and how to recognize the cut in trim.*

Materials. — Diagrams, school furniture, Hough's sections of woods.

Method. — Examine the sections shown you. Compare with lower figure, page 111, *Civic Biology*.

Note. — Most lumber is cut tangentially. Hence the yearly rings take a more or less irregular course. The grain of wood is caused by the fibers not taking straight lines in their course in the tree trunk. In many cases the fibers of the wood take a spiral course up the trunk, or they may wave outward to form little projections. Boards cut out of such a piece of wood will show the effect seen in many of the school desks, where the annual rings appear to form small elliptical markings.

Study the top of your desk, the wainscoting, the floor, and any other wood at hand to determine the kind of cutting. Study

the figures and compare with the specimens of wood just noted. Can you observe any differences in color of the wood?

Conclusion. — 1. What is the common method of cutting wood for trim? Why?

2. Does most dried wood show any difference between heart and sap wood? What is this difference?

***Problem 81**: To determine some uses of stems.*

Method. — See Chap. X, page 133, Hunter's *Essentials of Biology*, or Chap. IX, page 105, Hunter's *Civic Biology*. After reading carefully fill in the following table:

Substance	From what plant?	From what locality?
Cork		
Food		
Fuel		
Hemp		
Latex or Rubber		
Linen		
Lumber		
Quinine		
Resin		
Sugar		
Tannin		
Turpentine		
Wood Pulp		

Conclusion. — Write a paragraph summing up the uses of stems to man.

***Problem 82**: To determine the value of certain woods.*

Method. — Find out as many woods as you can that are of value because of properties listed in the following table and record in proper column. See Chap. X, Hunter's *Essentials of Biology*, or Chap. IX, Hunter's *Civic Biology*. After reading your text, or taking a trip to a commercial museum, fill out the table on page 98.

Paper Making	Durability and Strength	Softness	Beauty of Grain

Conclusion. — 1. Which woods are useful for skeletons of houses?

2. Which are useful for trim?

3. Which are useful for paper making?

4. In general, which are more used, soft or hard woods?

Problem 83: *Museum trip for study of woods.*

Materials. — Collection of commercial woods, or trip to a museum.[1]

Method and Observations. — Examine specimens of the most important commercial woods. Note such woods as:

white pine	spruce	sugar maple	white oak
black cherry	tulip	poplar	basswood
hemlock	fir	black oak	chestnut
hickory	walnut	cherry	white birch

Describe any six of the above, telling:

(*a*) The region where the trees grow.

(*b*) The shape of the leaves.

(*c*) The color of heart and sap woods.

(*d*) Comparative weight of the wood.

(*e*) Rapid or slow growth.

(*f*) Economic value.

Examine a specimen of a section of any big tree, such as a California big tree. Notice the so-called annual rings in the wood. About how old was this tree when it was cut?

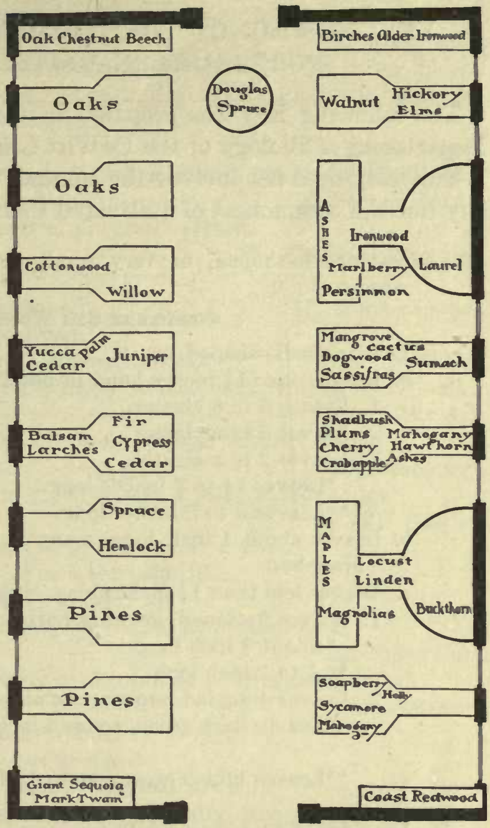
[1] A study such as here outlined may be made at any well-equipped city museum. Work of this nature may also be done in school by means of loan collections.

If you go to school in New York city use this diagram for your notebook.

Conclusion. — If a trip is taken, write out carefully a report of the observations made.

Problem 84: To identify common trees by the use of a key.

Materials. — Various specimens of wood with leaves on twigs; pictures of trees, flowers, and fruits; ruler.



A Diagram of the Hall containing the Jessup Collection of Woods, American Museum of Natural History, New York.

Method and Observations. — Using the material and the Key on the following pages under the supervision of your teacher, make *careful* observations of leaves given you. Note and measure size of leaf, structure, shape, etc. Refer to the Key which follows. Determine whether the specimen which you have belongs under A or B. If it belongs under A, for example, then place it under I or II. Having done this, determine whether it is *a*, *b*, or *c*, then 1, 2, or 3, etc., until you finally determine the specimen of leaf, and by it, the name of the kind of tree to which it belongs.

Conclusion. — What are the names of the various trees from which you have made observations?

KEY TO SOME OF THE COMMON TREES OF THE NORTHEASTERN UNITED STATES

The following Key was prepared by George T. Hastings of the Department of Biology of the DeWitt Clinton High School.

This Key does not include the common cultivated fruit trees, or any but the commonest of cultivated shade or ornamental trees.

A. Leaves, needle-shaped, or very small, scalelike. Evergreen trees, except No. 9.

Conifers or Soft Woods

I. Leaves needle-shaped.
  a. Leaves over 1½ inches long, in bundles of 2, 3, or 5.
    1. Leaves 5 in a cluster. 1. *White Pine.*
    2. Leaves 3 in a cluster. 2. *Pitch Pine.*
    3. Leaves 2 in a cluster.
      *Leaves 1½ to 3 inches long. 3. *Scotch Pine.*
      **Leaves 3 to 5 inches long. 4. *Austrian Pine.*
  b. Leaves about 1 inch long, many in a cluster on tiny knoblike branches. 5. *Larch* or *Tamarack.*
  c. Leaves less than 1½ inches long, singly on the twigs.
    1. Leaves flattened, growing horizontally on the twigs.
      *About ½ inch long. 6. *Hemlock.*
      ** ¾ to 1 inch long. 7. *Balsam.*
    2. Leaves 4 angled, growing on all sides of the twigs.
      *Leaves dark green, cones 4 inches or more long. 8. *Norway Spruce.*
      **Leaves bluish green, cones 1½ to 2 inches long. 9. *White Spruce.*
II. Leaves scalelike, very small.
  a. Leaves rounded, overlapping, flattened on the twigs, which appear as if ironed out flat. Fruit a cone about ½ inch long. 10. *White Cedar* or *Arbor Vitæ.*
  b. Leaves sharp-pointed, on all sides of the rounded or square twigs. Fruit a small blue berry. 11. *Red Cedar* or *Juniper.*

B. Leaves not needle-shaped or scalelike.

Broad-leaved or Hardwood Trees

I. Leaves in pairs, opposite on the branches.
  a. Leaves simple, palmately veined, notched or lobed.
    1. The depressions between the 3 to 5 lobes narrow, acute. twigs red.

*Leaves notched less than halfway to the midrib.
12. *Red Maple.*

**Leaves divided more than halfway. 13. *Silver Maple.*

2. The depressions between the lobes broad and rounded, twigs brown or greenish.
   *Twigs slender. 14. *Sugar Maple.*
   **Twigs stout, petioles when broken exude acrid milky sap, which coagulates. 15. *Norway Maple.*

b. Leaves simple, entire, pinnately veined.
16. *Flowering Dogwood.*

c. Leaves compound.
1. Palmately compound. 17. *Horse-chestnut.*
2. Pinnately compound.
   *Leaflets 3 to 5, coarsely dentate. 18. *Box Elder.*
   **Leaflets 5 to 9, finely serrate, each with a short stalk.
   19. *White Ash.*
   ***Leaflets 7 to 11, finely serrate, without stalks.
   20. *Black Ash.*

II. Leaves large, entire, growing 3 at a joint on the twigs.
21. *Catalpa.*

III. Leaves alternate on the twigs, one at a joint.

a. Leaves simple. (For *b* see page 103.)
1. Leaves palmately veined.
   *Leaves star-shaped, with 5 to 7 sharp lobes.
   22. *Sweet Gum.*
   **Leaves broadly oval, toothed or irregularly lobed.
   23. *Sycamore.*
2. Leaves pinnately veined.
   *Not deeply cut or lobed.
   †Leaves narrow, lanceolate.
   ·Twigs slender, not greatly drooping, leaves smooth and green both sides.
   24. *Fragile* or *Crack Willow.*
   · ·Twigs slender, not greatly drooping, leaves with small hairs and pale on both sides.
   25. *White Willow.*
   · · ·Twigs very slender, drooping, leaves smooth.
   26. *Weeping Willow.*
   ††Leaves broader, oval or ovate.
   ·Leaves dentate, smooth. 27. *Beech.*
   · ·Leaves serrate.
   'Bark on twigs and branches smooth, shining, black, bitter to the taste.
   28. *Black Cherry.*

"Bark not as in '.
:Leaves usually 4 inches or more long.
!Large sharp teeth on edges.
29. *Chestnut.*
!!Large rounded teeth on edges.
30. *Chestnut* or *Rock Oak.*
::Leaves less than 4 inches long.
!Leaves smooth, in more than 2 rows on the stem, bark peeling in thin sheets.
x. Twigs brown, bark with wintergreen flavor, bark dark brown or black.
31. *Black Birch.*
y. Twigs gray or yellowish, trunk silvery or grayish.
32. *Yellow Birch.*
z. Twigs brownish, bark chalky white.
33. *White Birch.*
!!Leaves rough, in 2 rows on the twigs.
x. Leaves very rough above, buds and twigs hairy, grayish, mucilaginous when chewed. 34. *Slippery Elm.*
y. Leaves slightly rough above, buds and twigs smooth or nearly so, brown or reddish, not mucilaginous.
35. *American Elm.*
†††Leaves as broad as long, or broader.
·Leaves sharp-pointed.
'Petioles (leafstalks) flattened at right angles to the blade.
:Tree tall, slender, branches all ascending.
36. *Lombardy Poplar.*
::Tree broader, leaves green.
37. *Carolina Poplar.*
:::Tree broader, leaves white below.
38. *White Poplar.*
"Petioles rounded.
39. *Basswood.*
··Leaves rounded at tip often with a lobe on one or both sides. 40. *Sassafras.*
···Leaves square, or notched at tip and sides.
41. *Tulip Tree* or *Tulip Poplar.*
**Leaves deeply cut or lobed.
†Lobes rounded. 42. *White Oak.*
††Lobes sharp-pointed.

·Lobes cut less than halfway to midrib, smooth, acorn large (1 inch long) with shallow cup. 43. *Red Oak.*

· ·Lobes cut more than halfway, acorns small (¾ inch or less), cup covering at least ⅓ of acorn.

'Leaves smooth both sides, scales of cup pressed down at tip. 44. *Scarlet Oak.*

"Leaves hairy below, at least in the angles of the veins, scales of cup spreading at tip. 45. *Black* or *Yellow-barked Oak.*

b. Leaves compound.

1. Trunks or branches thorny, leaflets rounded at the tip.

*Thorns large, often 3 parted. 46. *Honey Locust.*

**Thorns small; in pairs at the base of leaves, or sides of leaf scars. 47. *Common Locust.*

2. No thorns, leaflets pointed at tip.

*Twig very stout, ½ inch or more in diameter. Leaflets 11 or more.

†Twigs smooth. 48. *Ailanthus.*

††Twigs very hairy. 49. *Staghorn Sumach.*

**Twigs more slender, not over ¼ inch thick at tip.

†Leaflets 11 or more.

·Twigs smooth, nut round. 50. *Black Walnut.*

· ·Twigs downy, nut oval. 51. *Butternut.*

††Leaflets 9 or less.

·Bark of tree furrowed, not in long flat plates. 52. *Pignut.*

· ·Bark of tree in long flat plates loose at lower end. 53. *Shagbark Hickory.*

Problem Questions

1. What are the direct uses of stems to man?
2. What are the direct uses of stems to plants?
3. How are forests of value to man?
4. Name three enemies of the forests.
5. Name three ways of conserving our forests.
6. How do the forests of New York indirectly influence the commercial importance of New York city?
7. What special tree products give factories employment in your home city?
8. Of what value are trees in a city park?
9. Look in your *Civic Biology* and find ten ways in which trees are of value in a city.

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X. THE ECONOMIC RELATION OF GREEN PLANTS TO MAN

Problems. — *How green plants are useful to man.*
(*a*) *As food.*
(*b*) *For clothing.*
(*c*) *Other uses.*
How green plants are harmful to man.

Suggested Laboratory Work

If a commercial museum is available, a trip should be planned to work over the topics in this chapter. The school collection may well include most of the examples mentioned, both of useful and harmful plants.

A study of weeds and poisonous plants should be taken up in actual laboratory work, by collection and identification, or by demonstration.

To the Teacher. — This chapter, which is intended to sum up the preceding chapters from the practical aspect, may be made largely in the nature of reading and reports. It is wise when teaching a course in biology (or any other subject) to vary the work as much as possible, both to maintain interest and to prevent stagnation of thought on the part of the pupil.

Problem 85: *To determine the economic importance of some green plants.*

Materials. — Toothaker's *Commercial Raw Materials* is an invaluable reference book for this exercise. This might well be planned for a field and museum trip to some commercial museum, or the school museum may be used. Also visit the public or private markets in your locality and list all the food plants or their products used for food.

Method. — Fill out a table like the following.

Conclusion. — In what ways are green plants useful to man?

Fruits	Native	Cultivated	Uses to Man	Method of Preparing	Notes of Interest
Garden Fruits					
Beans					
Cucumbers					
Peas					
Pumpkins					
etc.					
Orchard Fruits					
Apples					
Apricots					
Cherries					
Peaches					
Pears					
Plums					
Quinces					
etc.					
Grains					
Barley					
Corn					
Oats					
Rice					
Rye					
Wheat					
etc.					
Miscellaneous					
Bananas					
Cocoa					
Coconut					
Coffee					
Cotton					
Pepper					
etc.					

***Problem 86**: To learn to know some green plants harmful to man.*

Materials. — Copies of Chestnut's *Thirty Poisonous Plants of the U. S.*, Farmers' Bulletin 86, and Dewey's *Two Hundred Weeds, How to Know Them and How to Kill Them*, Farmers' Bulletin 17. A few of the common plants which are weeds in your locality. (Poison ivy can be studied if placed in air-tight jars.)

Method and Observations. — Using Farmers' Bulletin 86, identify and give the characters by which you would know the following: pokeweed, corn cockle, black cherry, loco weed (very harmful in the West), snow-on-the-mountain, poison ivy, poison oak, poison sumac, water hemlock, poison hemlock, poison weed, black nightshade. Using Farmers' Bulletin 17, identify and classify ten of the most common weeds of eastern United States.

Conclusion. — 1. Write a paragraph on some one poisonous plant and the best means of eradicating it from your vicinity.

2. Make a table modeled after the following. In it place any ten plants in which you are interested. Fill out completely.

Weeds	Habitat	Estimated Loss	What harm they do
Dandelion			
Canada Thistle			
Cocklebur			
Milkweed			
Oxeye Daisy			
Pigweed			
Purslane			
Ragweed			
Wild Carrot			
Wild Lettuce			
etc.			

Problem Questions

1. What effect ought plant products in a given locality to have on the prices of animal products having the same food value? Is this true, in your opinion? Get your teacher to help you interpret this question.
2. Name ten food plants grown in your locality.
3. Name ten food plants that must be imported for our use.
4. Using the school or other museum, make a report on three different fiber plants, giving their habitat, method of manufacture from raw materials, and their ultimate uses by man.
5. Name five plants used for medicine.
6. Discuss the value of some one plant just mentioned as a specific remedy against some particular disease.
7. Show three ways in which weeds may do harm to man.

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XI. PLANTS WITHOUT CHLOROPHYLL IN THEIR RELATION TO MAN

Problems. — *(a) How molds and other saprophytic fungi do harm to man.*

(b) What yeasts do for mankind.

(c) A study of bacteria with reference to

(1) Conditions favorable and unfavorable to growth.

(2) Their relations to mankind.

(3) Some methods of fighting harmful bacteria and diseases caused by them.

Laboratory Suggestions

Field work. — Presence of bracket fungi and chestnut canker.

Home experiment. — Conditions favorable to growth of mold.

Laboratory demonstration. — Growth of mold, structure, drawing.

Home experiment or laboratory demonstration. — Conditions unfavorable for growth of molds.

Demonstration. — Process of fermentation.

Microscopic demonstration. — Growing yeast cells. Drawing.

Home experiment. — Conditions favorable for growth of yeast.

Home experiment. — Conditions favorable for growth of yeast in bread.

Demonstration and experiment. — Where bacteria may be found.

Demonstration. — Methods of growth of bacteria, pure cultures, and colonies shown.

Demonstration. — Foods preferred by bacteria.

Demonstration. — Conditions favorable for growth of bacteria.

Demonstration. — Conditions unfavorable for growth of bacteria.

Demonstration by charts, diagrams, etc. — The relation of bacteria to disease in a large city.

To the Teacher. — In these days when the application of biology to human welfare is so often made the chief aim of a course in biology, it is refreshing to know that there are teachers left who believe in logic and in the building of a superstructure before proceeding to work upon the top of the building. In point of interest and of instructive value, the exercises which follow are vital; as experiments, however, they are not always absolutely to be relied upon. The extreme delicacy with which some of the factors work, the fact that we are dealing with microörganisms which cannot be handled except in bulk, the fact that most school laboratories have neither equipment nor means to obtain some of the necessary materials, make absolutely accurate experiments sometimes out of the question.

The *method* of science can, however, be used and all reasonable care and accuracy be given in the performance of any experiments which follow.

The informational content is certainly of the widest possible importance. An entire course could well be devoted to the numerous experimental questions which present themselves. It is unwise, however, to give more than a month to six weeks' time to the chapter because of the need for balance in the course.

Materials for the study of bacteria (nutrient agar or gelatine) may be obtained from any good chemist, from manufacturing chemists, and from the local board of health. Directions for making culture media follow in this chapter, but the work need not be given up because of lack of proper apparatus or laboratory facilities.

Problem 87: To determine the relation of fungi to the destruction of certain trees.

NOTE. — Suggestions for field trip to work out loss of trees by the attack of shelf fungus and chestnut canker. A field trip to a park or grove near home may show the great destruction of timber by these means.

a. Shelf Fungus

Observations. — Count the number of perfect trees in a given area. Compare it with the number of trees attacked by the shelf fungus. Does the fungus appear to be transmitted from one tree to another near at hand? In how many instances can you discover the point where the fungus first attacked the tree? Do healthy trees seem to be attacked?

Conclusion. — Under what conditions will shelf fungus attack a tree?

b. Chestnut Canker

NOTE. — Chestnut canker is spread by tiny reproductive bodies called *spores*. These, if they obtain a foothold on a sound tree, soon grow to form plants which feed upon the tree, ultimately causing its death.

Observations. — In a given area are all the chestnut trees dead or dying? How might tiny spores get from one tree to another? What appears to be the first sign of the disease in a tree? Pull off the bark of an infected tree and note the silvery threads running in every direction. These form the body of the canker called the *mycelium*, which reaches out after food. What part of the tree would it be likely to attack and why?

NOTE. — A plant or animal which lives at the expense of another living plant or animal is called a *parasite*.

Is the canker a parasite?

Conclusion. — 1. What will a parasite eventually do to the host on which it lives?

2. Why is chestnut canker an enemy to man?

3. Why is it so difficult to combat?

Problem 88: *To determine the conditions favorable for the growth of mold.*

Materials. — Four wide-mouth jars or bottles, bread.

Method. — Place a piece of bread in each of the four wide-mouth bottles or jars, add a little water, and expose all four to the air of the living room or kitchen for half an hour. Then cover all the jars and plunge one into boiling water for a few moments; place this and a second jar side by side in a moderately warm room. Place the third jar in the ice box and the fourth in a hot and dry place.

Observations. — 1. Notice day by day any changes that occur in the contents of the jars.

2. In which jar does growth appear first?

3. Do all jars have a like growth of mold at the end of a given period of time?

Conclusion. — 1. How does the mold get on the bread?

2. Where does it come from?

3. Why did we add water to the jars?

4. What conditions must you have for the growth of mold?

5. Conversely, how would you keep molds from getting a foothold on foods?

Problem 89: *To study the structure of bread mold.*

Materials. — Bread mold. Figure page 133, *Civic Biology*.

NOTE. — *Directions for Growth of Mold.* — Bread mold may be conveniently grown for laboratory use in small shallow dishes (Syracuse watch glasses, Petri dishes, or butter chips). If bread is exposed to the air for a few minutes and then left in the covered dishes for a day or two, with a bit of wet sponge or blotting paper in the dish to keep the air moist, a good supply of mold may be obtained in a convenient dish for observational purposes.

Observations. — Examine the tangled mass of threads which cover the bread. This is called the *mycelium*, each thread being called a *hypha*. How do the hyphæ appear to be attached to the bread?

NOTE. — Some of these threads reach down into the bread and act as roots, digesting and absorbing nourishment. These are called *rhizoids*. Many of the hyphæ are prolonged into tiny upright threads, bearing at the top a little ball. This is called the *sporangium*.

With the low power of the microscope the structure of a sporangium may be made out. The dark-colored ones are full of ripe spores, which may be seen by lightly tapping the cover slip over the slide. How do the spores get out of the sporangium? Try to find some young sporangia and note the differences in size and color between them and the older ones.

Conclusion. — 1. How does bread mold get its food?

2. How do you know that it cannot manufacture its own food? Explain.

3. Have you seen any other kinds of molds on foods? If so, on what foods?

4. What effect do molds have on food?

5. What are the spores on bread mold for?

6. What effect do their size and numbers have on the spread of the mold?

Drawings. — Draw a series of sporangia as seen under the low power.

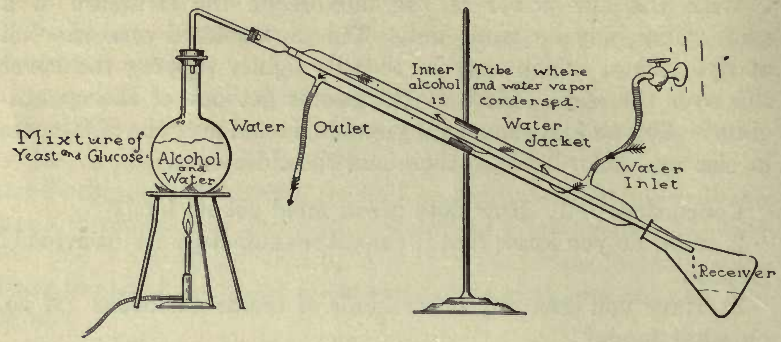
Problem 90: What is fermentation and what causes it?

Materials. — Fermentation tube, yeast, molasses, test tube, Erlenmeyer flask, limewater, absorbent cotton, cork, and delivery tube.

Method. — Carefully fill a fermentation tube with a mixture of molasses, water, and a little piece of compressed yeast cake. Plug the open end with absorbent cotton. Put in a warm place over night. Partly fill an Erlenmeyer flask with a mixture of molasses, water, and compressed yeast cake. Close the flask with a stopper fitted with a delivery tube which leads into a test tube filled with limewater.

Observations. — What has happened to the filled end of the fermentation tube? How do you account for this? Smell the contents of the flask after a day or two. What is this odor? What has happened to the limewater?

Conclusion. — 1. What happens when fermentation takes place?
2. What gas is formed? Explain fully.
3. What substance is present in the flask? How do you know?



Apparatus to prove that Alcohol may be distilled from Fermenting Yeast.

Note. — If we were to distill off the contents of the Erlenmeyer flask, we could prove the presence of alcohol. Fermentation is the process which breaks up sugar ($C_{12}H_{22}O_{11}$) into carbon dioxide (CO_2) and alcohol (C_2H_5OH).

Problem 91: *To learn to recognize yeast plants under the compound microscope.*

Materials. — Compound microscope, nutrient solution containing growing yeast plants from a compressed yeast cake (composed of food and yeast plants), iodine. Lower figure, page 136, *Civic Biology.*

Method. — Place a drop of solution on a slide and add iodine.

Observations. — Note the dark blue bodies. What are they? (Remember the iodine test.) The smaller ovoid bodies are the yeast cells. What color are they? Shape? Do you find any budding (one growing out from another cell)? Note the clear areas (*vacuoles*) within the cells.

Conclusion. — 1. Write a paragraph descriptive of yeast cells and their method of reproduction.

2. Draw a few cells showing budding. Add a starch grain for comparison. Draw both to scale.

Problem 92: Do yeasts grow wild?

Materials. — Molasses or nutrient solution, Petri dish, fermentation tube.

Method. — Place a Petri dish, or other flat dish, with nutrient solution in it for a day in any locality exposed to ordinary drafts of air. Then pour its contents into a fermentation tube and plug with absorbent cotton.

Observations. — Note any change in the contents of the closed end of the tube.

Conclusion. — 1. Is there any yeast present? If so, where did it come from?

NOTE. — Spores (reproductive bodies) of yeast are found in the air, and yeasts grow on grape, apple, pear, and other fruit skins.

2. What causes wine to ferment, cider to become hard (ferment), etc.?

Problem 93: To determine the conditions favorable to the growth of yeast.

Materials. — Fruit jars, yeast cake, molasses.

Method. — Label three pint fruit jars A, B, and C. Add one fourth of a compressed yeast cake to two cups of water containing two tablespoonfuls of molasses or sugar. Stir the mixture well and divide it into three equal parts and pour them into the jars. Place covers on the jars. Put jar A in the ice box on the ice and jar B over the kitchen stove or near a radiator; boil jar C by immersing it in a dish of boiling water, and place it next to B. After forty-eight hours, look to see if any bubbles have made their appearance in any of the jars.

Observations. — Which jars, if any, show bubbles on the surface? After bubbles have begun to appear at the surface, the fluid in jar B will be found to have a sour taste and will smell unpleasantly. The gas which rises to the surface, if collected and tested, will be found to be carbon dioxide.

Conclusion. — 1. What conditions are favorable for the growth of yeast?

2. How do you know that yeast has grown?

***Problem 94**: What are the conditions favorable for the growth of yeast in bread?* (Home work.)

Materials. — Flour, water, sugar, salt, yeast cake, pans.

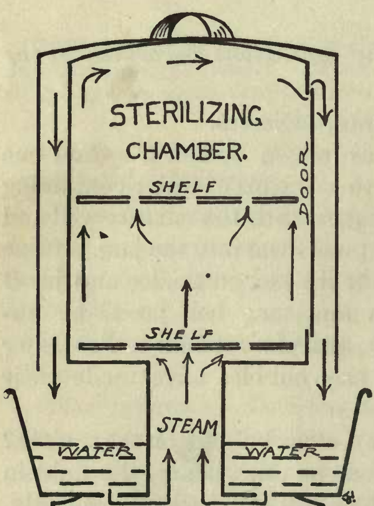
Method. — Make a dough by mixing flour, sugar, salt, and water in proportions to make a thick paste. Knead with a little yeast which has previously been mixed with water. Now place one lot of dough in the ice box, one at the temperature of the room, and one in a warm place (over 90° F.). Later bake each lot and use in the laboratory.

Observations. — Which of the three lots has raised the most? Which, after baking, has the best appearance? The best taste? What makes the holes in the bread?

Conclusion. — 1. What caused the bread to rise?

2. Under what conditions does this best take place?

Experiments with yeast may be continued almost indefinitely. For excellent suggestions, see Conn's *Bacteria, Yeasts, and Molds in the Home*, pp. 274–278.



Heat applied under the sterilizer turns the water into steam, which circulates through the holes in the shelves, escapes between the door and the inner jacket, and returns as water after condensing between the inner and outer jackets of the sterilizer.

***Problem 95**: How we proceed to the study of bacteria.*

Materials. — Dry sterilizer, steam sterilizer, Petri dishes, fermentation tubes, pipettes, and compound microscope.

Several pieces of apparatus are useful though not indispensable in the study of bacteria. All of this apparatus should be shown to the pupils and its use explained. Older pupils should be encouraged to assist in preparing the culture media and in the subsequent sterilization of the material. Sterilizers may be improvised by using two pans, one of which fits closely

over the other. Any sheet-iron or tin box that will stand heating red-hot may be used as a dry sterilizer.

Methods. — Study the construction of the steam and dry sterilizers.

NOTE. — Sterilization means the raising of the temperature to such a degree of heat as will kill all germs.

Conclusion. — How is the sterilizer fitted to do its work?

Problem 96: How to prepare culture media.

Method. — Beef bouillon which has been cleared and filtered may be used for growing bacteria.

Nutrient agar-agar[1] is the best medium in which to grow bacteria. It may be prepared from the following materials: 1000 c.c. water, 10 g. salt, 10 g. peptone, 10 g. Liebig's beef extract, a little cooking soda, and 10 g. agar-agar. If agar-agar cannot be obtained, use 100 g. of the best French gelatin.

Dissolve the beef extract in the 1000 c.c. water. Cut the agar into pieces and add with the salt and peptone. The mixture must then be heated to cause the agar to dissolve, care being taken that it does not burn. Enough cooking soda is added to cause red litmus paper dipped in the mixture to turn blue, *i.e.*, the liquid should be *faintly* alkaline. Filtering hot agar should be carried on within the steam sterilizer. A glass funnel should be put in the mouth of an Erlenmeyer flask and one or two layers of absorbent cotton placed within the funnel. If the agar, flask, and funnel are kept hot within the sterilizer, the liquid will readily pass through the cotton. After filtering, the mouth of the flask should be closed with a plug of absorbent cotton. Then boil in the cooker for half an hour. If the agar mixture is not clear, it should be filtered through cotton a second time. If care has been taken, the nutrient solution is now ready for use, and may be set aside as a stock solution.

If it is desired to make a nutrient solution for molds, omit the cooking soda and add a few drops of *dilute* hydrochloric acid; because molds grow best in a slightly acid medium, while bacteria thrive in a slightly alkaline medium.

[1] Agar-agar is a preparation from seaweed which gives an excellent vegetable gelatin (a protein food).

To prepare the nutrient agar-agar for use, it may be poured while hot into Petri dishes which have been previously sterilized with dry heat for several hours and then kept in a dry place free from dust. It is well to sterilize the plates once or twice after they are coated, using a steam sterilizer.

Test tubes partially filled with the nutrient jelly are also useful. Immediately after pouring the hot jelly into the test tubes they should be plugged with absorbent cotton and then placed in the steam sterilizer.

Problem 97: *To demonstrate a pure culture.*

Materials. — Culture media in Petri dishes, one dish containing colonies of bacteria; sterile needle.

Method. — The instructor transfers some of a colony of bacteria on the point of a sterile needle to the sterile surface of a new Petri dish which has in it nutrient jelly. Watch the growth of the colony on subsequent days.

Observations. — How long before colonies appear on the surface? Are these colonies all alike in appearance?

Conclusion. — Have you obtained a pure culture? If so, how did you do this?

To the Teacher. — In this and all the problems that follow, the teacher should be ready to start the experiments at least three or four days before they are to be used in class laboratory for demonstration. Pupils should be led to notice the conditions at the beginning of an experiment which may be several days before any notes or drawings are expected from their observations. Interest will be held by discussing beforehand the nature of the problem and by making sure that the pupil knows the aim of the experiment. Far too much work in our laboratories is blind, unreasoning, busy work following directions that lead nowhere. At the beginning of these experiments in bacteriology, the instructor should make sure by demonstration that the pupil knows what to work for on a plate and in a tube. The making of a pure culture should be shown, not so much because it will be a *pure* culture as to impress at the start the need for extreme care in making all of these experiments. Pupils at the outset should be taught to recognize bacteria by (*a*) odor, *e.g.*, decay; (*b*) change in appearance of nutrient media, *e.g.*, cloudiness of bouillon; and (*c*) appearance of colonies. Microscopic demonstration is interesting but unnecessary with young students. A scale drawing on the board or on the chart means much more to the average pupil.

Problem 98: *To determine where bacteria may be found.*

Materials. — A number of covered Petri dishes containing sterile agar.

Method. — Expose a number of these Petri dishes containing nutrient for the same length of time in as many of the following conditions, and as many others, as possible:

(*a*) to the air of the schoolroom.
(*b*) in the halls of the school while pupils are passing.
(*c*) in the halls of the school when pupils are not moving.
(*d*) at the level of a dirty and much-used city street.
(*e*) at the level of a well-swept and little-used city street.
(*f*) in a city park.
(*g*) in a factory building.
(*h*) to dirt from hands placed in dish.
(*i*) to contact with the interior of the mouth.
(*j*) to contact with decayed vegetable or meat.
(*k*) to contact with dirty coin or bill.
(*l*) to contact with two or three hairs from pupil's head.

Petri Dish Exposed	Number of Colonies of Bacteria							
	5th Day	6th Day	7th Day	8th Day	9th Day	10th Day	11th Day	12th Day
a Air of Schoolroom								
b Busy Halls of School								
c Quiet Hall of School								
d Busy City Street								
e Etc.								

Observations. — After three to five days note the conditions of the various plate cultures. Each day count the number of spots (*colonies*) of bacteria and molds growing on the culture medium. Make a table like the above to show your results.

Conclusion. — 1. Where are bacteria found in greatest numbers?

2. What are the factors in your environment by means of which bacteria might get to your body?

***Problem 99**: To study how rapidly bacteria grow.*

Method. — Imagine that you have inhaled a germ causing cold or consumption (*bacillus tuberculosis*) while riding on the subway train or street car at 8.30 A.M. You are in such poor physical condition that the bacterium can grow and multiply. Scientists who have studied germs (bacteriologists) tell us that the bacterium

causing consumption divides every half hour. Make the following table complete for 24 hours, using numbers only.

8.30	A.M.	a bacterium taken in	= 1
9.00	"	the " divides	= 2
9.30	"	the bacteria divide again	= 4
10.00	"	and "	= 8
10.30	"		= 16
11.00	"		= 32
11.30	"		= 64
12.00	M.		= 128
12.30	P.M.		= 256
etc.,	"		

Conclusion. — 1. How many bacteria would there be in your lungs at 8.30 A.M. the following morning?

2. Why do we not catch some disease each day? We breathe, eat, and drink countless dangerous bacteria every day. (See page 154, *Civic Biology*.)

Problem 100: *What foods are preferred by bacteria?*

Materials. — Raw meat, cooked meat, white of egg, beans, Indian meal flour, cake, sugar, butter, test tubes, absorbent cotton.

Method. — Moisten all of the above food substances, place in test tubes with a little water. Expose all to the air for half an hour. (This can be done during a class period.) Plug with absorbent cotton and allow to stand for several days.

Observations. — Note the appearance and odor of the various substances after five days.

Conclusion. — 1. In which substances was there rapid growth of bacteria?

2. Can you make any generalization with reference to the class of nutrients most favorable for the growth of bacteria?

Problem 101: *What effect has heat upon the growth of bacteria?*

Materials. — Test tubes, bouillon.

Method. — Number four tubes containing bouillon. Place

number 1 in the ice box, number 2 in a dark box at a moderate temperature, number 3 in a box at a hot temperature (100° F. or over), and boil number 4 for 15 minutes and then place with number 2.

Observations. — In which tube does the greatest amount of growth take place? (Note the odor as well as color of bouillon.) In which tube did the least growth take place?

Conclusion. — What is the effect of intense heat upon bacteria? From this experiment we derive the very important method of fighting bacteria by means of *sterilization*. From experiments already performed give a definition of sterilization.

Problem 102: *To note the effect of moisture and dryness upon the growth of bacteria.* (Home problem.)

Materials. — Beans, test tubes.

Method. — Take two beans. Remove the skin and crush one. Soak the second bean overnight and then crush it. Place in test tubes, the first dry, the second with water. Leave both in a warm place for two or three days. Then smell each tube.

Conclusion. — 1. In which is decay taking place?

2. In which tube are bacteria at work? How do you know?

NOTE. — Heat and dryness are thus shown to be unfavorable to the growth of bacteria. From experiments dry sterilization, if continued long enough and if the heat is sufficiently high, seems the more effective.

Some foods are spoiled by too great heat. Milk, in particular, is changed by boiling so as to be quite a different food. Hence a method of killing germs known as *pasteurization* is of importance.

Problem 103: *To determine the effect of pasteurization upon the keeping quality of milk.*

Materials. — Milk, two sterilized covered jars, thermometer, double boiler, or pasteurizing apparatus.

Method. — Place half of the milk in a sterilized jar, cover, and leave in a warm place for 24 to 48 hours.

Place the remainder of the milk in the other jar, cover, and put it in the double boiler or pasteurizing apparatus. Bring the hot water surrounding the jar from 160° to 180° F. for about 30

minutes. This is known as pasteurization. Afterwards treat exactly as you did the first jar of milk.

Observations. — What is the odor of milk in each jar after 24 and 48 hours? What is the taste of the milk in each jar after 24 and 48 hours?

Conclusion. — 1. What are found in milk that cause it to sour? How do you know?

2. What is the use of pasteurization?

Problem 104: How to care for milk bottles at home.

Materials. — Recently used milk bottles.

Method. — Place a recently used milk bottle in a warm place for 24 hours. Note the odor. Rinse out a second milk bottle with cold water, a third with boiling water. Set aside and note odor after 24 hours, as before.

Observations. — Describe the odor. Note any differences in odor in the three bottles.

Conclusion. — How should milk bottles be treated to prevent rapid souring of milk?

Problem 105: To determine the bacterial content of milk.

Materials. — Sterile Petri dishes containing agar culture media, a sample of milk.

Method. — Milk should be collected by pupils from some near-by source as, for example, the lunchroom of the school. To 1 c.c. of this milk add 19 c.c. of distilled water in a sterile pipette. Shake well and then flood the surface of a sterile Petri dish with the mixture. Pour off all excess fluid. Then cover quickly and place the dish in a moderately warm place.

Observations. — Notice that after 24 hours (or even less if the temperature is warm) colonies of bacteria appear on the surface of the culture media. Note the number of colonies of bacteria present on the second, fourth, and sixth days after preparing the experiment.

Conclusion. — 1. What can you say of the number of bacteria in this milk?

2. What do bacteria do to the milk? (Smell the Petri dish.)

NOTE. — A similar experiment should be tried with water from various sources. Bottled drinking water, rain water, artesian well water, tap water, and water collected from surface pools are suggested for possible experiments.

Problem 106: *To determine some of the most effective preservatives.*

Materials. — Test tubes containing beef bouillon and various preservatives, salt, sugar, vinegar, formalin, boracic acid, alcohol.

Method. — Expose the tubes to the air unplugged. Number the tubes and label them.

To No. 1 add nothing.
No. 2 add ¼ spoonful of salt.
No. 3 add 1 spoonful of sugar.
No. 4 add a saturated sugar solution.
No. 5 add 1 spoonful of vinegar.
No. 6 add a few drops boracic acid (saturated solution).
No. 7 add ½ spoonful boracic acid.
No. 8 add 5 drops formalin.
No. 9 add 1 spoonful alcohol.

Observations. — Note the appearance, odor, and color of each tube at the end of three days, five days, one week, and two weeks. Tabulate your results as shown in accompanying chart.

Appearance and Odor	Nothing Added	½ Spoonful of Salt	1 Spoonful Sugar	Saturated Sugar Solution	1 Spoonful of Vinegar	5 drops Boracic Acid	½ Spoonful Boracic Acid	5 drops Formalin	1 Spoonful Alcohol
At End of 3 Days									
At End of 5 Days									
At End of 1 Week									
At End of 2 Weeks									

Conclusion. — 1. What are the most effective preservatives?

2. Which of the above are permitted by law? (See Hunter's *Civic Biology*, p. 148.)

3. On which solutions did mold grow?

4. Which preservatives prevented bacteria but not molds?

5. Which preservatives prevented the growth of both bacteria and molds?

Problem 107*: *To determine the most effective disinfectants.

Materials. — Use tubes of bouillon containing different strength solutions of formalin, lysol, iodine, carbolic acid, and bichloride of mercury.

Method. — Expose all tubes unplugged to air, having previously inoculated each tube with germs from a Petri dish culture. Number and label tubes.

To tube 1 add 1 drop formalin.
2 add 5 drops formalin.
3 add 1 drop lysol.
4 add 3 drops lysol.
5 add 1 drop iodine.
6 add 5 drops iodine.
7 add 4 drops carbolic acid.
8 add 10 drops carbolic acid.
9 add 1 drop bichloride mercury solution.
10 add 5 drops bichloride mercury solution.

Observations. — Tabulate daily for a week or more the results for the contents of each tube on a table as shown below.

Conclusion. — 1. Which of the above is the best disinfectant? Why do you answer as you do? (Remember that according to definition an *antiseptic* may retard the growth of bacteria but will not of necessity kill them; a *germicide* destroys all bacteria *if used properly;* while a *disinfectant* is a solution used to kill disease germs, usually in the excreta of sick people.)

Appearance and Odor at the End of	1 Drop Formalin	5 Drops Formalin	1 Drop Lysol	3 Drops Lysol	1 Drop Iodine	5 Drops Iodine	4 Drops Carbolic Acid	10 Drops Carbolic Acid	1 Drop Bichloride Sol.	5 Drops Bichloride Sol.
3 days										
5 days										
1 week										
2 weeks										

2. Using the data from the last two problems, classify the materials used, as antiseptics, germicides, or disinfectants. Give reason for each.

Problem Questions

1. Fill out the accompanying comparative table:

	Mold	Yeast	Bacteria
Drawing			
Size			
Conditions Favorable For Growth			
Conditions Harmful To Growth			
Use to Man			
Harm to Man			

2. Where may mold spores be found? What must they have in order to grow?

3. On what part of foods do molds grow?

4. How would you prevent mold spores from getting into food?

5. Is food that has become moldy fit to eat? Explain.

6. Why are we able to eat moldy jelly after removing the mold?

7. How may molds be harmful to man? Useful to man?

8. How may yeasts be useful to man?

9. Where are yeasts found? Give proofs.

10. What products are formed when bread rises? What becomes of these products?

11. It is said that yeast plants are at once the friends of man and yet make him their slaves. Explain what this means.

12. Why do we place foods in the ice box?

13. Why are some meats and fish salted?

14. Why are some meats and fish smoked?

15. Why is corn, wheat, or other grain stored in a dry place?

16. Why do canned goods keep?

17. Why are preserves sometimes not fit to eat?

18. Why do we place eggs in salt, liquid glass, or coat them with paraffin in order to keep them?

19. How would you prevent milk from souring?

20. What would you do to prevent the possible spread of disease germs in your home if you had a case of typhoid fever there? Tuberculosis? Grippe?

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XII. THE RELATIONS OF PLANTS TO ANIMALS

Problems. — *To determine the general biological relations existing between plants and animals.*

(*a*) *As shown in a balanced aquarium.*

(*b*) *As shown in hay infusion.*

Suggestions for Laboratory Work

Demonstration of life in a "balanced" and "unbalanced" aquarium. — Determination of factors causing balance.

Demonstration of hay infusion. — Examination to show forms of animal and plant life.

Tabular comparison between balanced aquarium and hay infusion.

To the Teacher. — The gap between plants and animals is not a wide one. The bridging of the gap is undertaken by means of the exercises which follow. First the pupil is led to see the interdependence of organisms on the earth; then the dependence of one kind of organism upon another; and then he is brought face to face with the fact that there are two kinds of organisms, one constructive, the other destructive. These, he learns, may both live in a small aquarium jar and they may both be single cells.

Problem 108: *To study some biological relations of plants and animals in a balanced aquarium.*

Materials. — A *balanced* aquarium containing living green plants, fish, tadpoles, snails, and other forms of animal life.

Observations. — Watch the animals within the aquarium to see if any are feeding. Note what they eat, also that the fish are continually opening their mouths as if biting. What might the fish be taking from the water (not food)? In an aquarium placed in the sunlight, what gas is given off from the green plants? How might this gas be useful to animals?

Does this explain the action of the fish mentioned above? What gas is given off by animals that plants would use under certain conditions? Are these conditions present? Fish and other ani-

mals give off nitrogenous wastes. How might these be used by the plants in the aquarium?

Conclusion. — 1. What might the plants within the aquarium furnish the animals? What might the animals furnish the plants?

2. Remembering that the sun furnishes energy, tell what makes the *balance* within the aquarium. How could you destroy this balance?

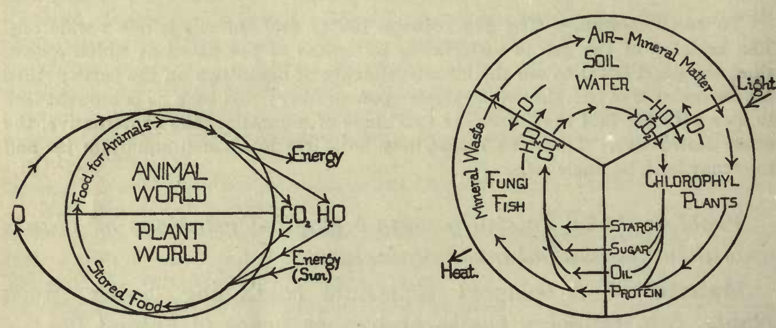
3. Fill out the accompanying balance sheet.

Balanced Aquarium

Contents	Income from	Outgo to
Animals		
Plants		

***Problem 109**: To learn what we mean by the carbon and the oxygen cycles.*

Method. — Carefully study the following figures.



a. Carbon Cycle

Observations. — In the plant world where does the carbon come from? Trace it to the animals. In what form do they take it in? In what forms do they release it? How does carbon get back to the plants?

b. Oxygen Cycle

Observations. — Begin with animals. What happens to oxygen within their bodies? In what form does it leave the animal body?

How does it get to the plant? Does the plant use oxygen as the animal does?

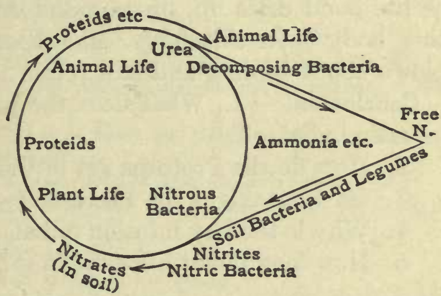
Conclusion. — 1. How are plants able to store up energy? Where does it come from? What becomes of it?

2. Explain the carbon cycle.

3. Explain the oxygen cycle.

***Problem 110**: To find out the course of nitrogen in its relation to plants and animals.*

Method. — Begin at the point of the diagram marked "Free N," following the direction of the arrows.



Observations. — What do we mean by "free nitrogen"? Where is it found? How do green plants get the free nitrogen? In what form does the nitrogen get into the animal body? In what form does the nitrogen leave the bodies of animals? What causes this material and the dead bodies of animals to become usable by plants? Does any nitrogen get back into the atmosphere again? If so, how and when? Look this up in any good book of reference.

Conclusion. — 1. Fill out a summarizing table like the accompanying.

Plants	Income of/from Animals	Outgo of/to Animals
Green		
Bacteria		

2. In your notebook explain in a well-written paragraph what is meant by the nitrogen cycle.

***Problem 111**: To prove a hay infusion is an unbalanced aquarium.*

Materials. — Hay, glass jar, microscope, glass slides, cover glasses, and pipette.

Method. — Make a hay infusion by placing a wisp of hay in a jar of warm water. Let it stand a few days.

Observations. — What has happened to the hay? Any change in color? Appearance? Odor? What do you know has happened to materials within the hay infusion?

With a bulb pipette take a drop of water from the edge of the jar near the surface of the water. Place it on a glass slide. Examine with the low power of the compound microscope. The tiny structures moving about are one-celled animals.

Grass for hay is often cut near pools that dry up at haying time. These pools contain millions of one-celled animals (*Protozoa*) which, as the pond dries up, proceed to form a heavy wall about each tiny body. In this form (like spores of mold) they may be blown about in dust and still retain their vitality.

Conclusion. — 1. What does the presence of decay in the hay infusion indicate?

2. How do the Protozoa get in the infusion?
3. On what might the Protozoa feed?
4. Why is the hay infusion unbalanced?
5. How long might life exist in it?

Problem Questions

1. Why is an aquarium called *balanced?*
2. What factors are necessary for the balance?
3. What are the food relations existing between plants and animals in an aquarium?
4. Compare life on the earth to a balanced aquarium.
5. What kinds of bacteria are necessary to life on the earth? Why?
6. What substances are formed through the influence of the bacteria of decay?
7. What is meant by the carbon cycle?
8. What do you understand by the oxygen cycle?
9. Explain the nitrogen cycle in an aquarium; on the earth.
10. What are the indispensable bacteria? Why?
11. In what stage must the one-celled animals have been when they were attached to the hay? Why?

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XIII. SINGLE-CELLED ANIMALS CONSIDERED AS ORGANISMS

***Problems.** — To determine:*

(*a*) *How a one-celled animal is influenced by its environment.*

(*b*) *How a single cell performs its function.*

(*c*) *The structure of a single-celled animal.*

Laboratory Suggestions

Laboratory study. — Study of paramœcium under compound microscope in its relation to food, oxygen, etc. Determination of method of movement, turning, avoiding obstructions, sensitiveness to stimuli. Drawings to illustrate above points.

Laboratory demonstrations. — Living paramœcium to show structure of cell. Demonstration with carmine to show food vacuoles and action of cilia. Use of charts and stained specimens to show other points of cell structure. Laboratory demonstration of fission.

To the Teacher. — With the introduction given by the previous chapter, it is easy to demonstrate some of the reactions of a single-celled animal, and compare them with those of a single-celled plant. The structure of a cell and its various functions as an organism make this chapter of great interest to all pupils, especially as the wonders of the world of the microscope are placed at their disposal.

***Problem 112:** To study a one-celled animal in order to understand better* (*a*) *its reactions to stimuli;* (*b*) *the cell as a unit of structure.*

Materials. — Hay infusion, pipette, glass slides, cover glasses, and compound microscope, Kny or Leukart charts.

Method. — Remove, by means of a pipette, a few drops of the whitish scum on the top of the hay infusion. This scum contains great numbers of *paramœcia* (a one-celled animal). Mount on a slide with a little *spirogyra* or other green alga. After allowing slide to stand for a few moments, examine under the low power.

a. Reaction to Stimuli

Observations. — Do the moving structures appear to have any definite shapes? Do they move with any definite end forward? Do they collect in any locality? If so, what influences them to do this? Heat a needle and introduce at one side of the cover glass. Any movement on the part of the paramœcia? Notice some of the animals grouped around masses of food. Why do you suppose the paramœcia are there? Notice other paramœcia with reference to the position of air bubbles or to threads of spirogyra. How do they lie with reference to the air bubble? What might the animal get from the air bubble if it is to do work? How would a cell covered with a membrane take anything from an air bubble? What might it give in exchange?

NOTE. — All things that influence a plant or animal to react are called *stimuli*.

Conclusion. — 1. Write a paragraph explaining how a paramœcium reacts to the stimuli in its environment.

2. Make drawings to illustrate your conclusions.

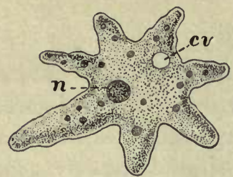
b. Movement

Observations. — Look at the chart or at the prepared material for tiny projections from the body walls of the paramœcium. These structures, which are flexible threads of living matter, are called *cilia*.

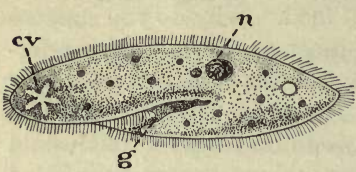
Conclusion. — How might locomotion be accomplished by means of cilia? Explain with the aid of a diagram.

c. Internal Structure

Observations. — To study the internal structure of paramœcia use living animals which have been fed on green microscopic plants or on carmine grains. Examine with high power and also use charts. The small round spaces filled with green plant material or with red carmine grains are *food vacuoles*. Look for a groove on one side of the cell; this leads into a funnel-like opening, the *gullet* (*g*). (See page 134.) Explain how food might be taken in by a paramœcium. How might it circulate within the body?

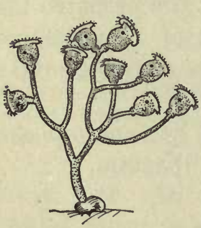


Amoeba



Paramœcium

Vorticella



A Colonial Type

Remember that the paramœcium is a semi-fluid body, covered with a membrane.

Other structures found within the cell are (1) *contractile vacuoles* (*cv*), usually one at each end of the cell; these serve to excrete liquid waste; (2) *water vacuoles*, clear spaces; (3) the *nucleus* (*n*), consisting of a double structure, the *micro-* and the *macro-nucleus* which can be seen only in a stained specimen. (Demonstration.)

Conclusion. — 1. What structures are found in a one-celled animal?

2. What uses have these structures?

3. Draw a paramœcium showing all structures.

d. Reproduction

Observations. — Sometimes paramœcia may be found dividing crosswise by fission. In this process each of the two new cells formed contains half the original nucleus and half of the rest of the cell body. Draw such a specimen if you find one. In another method of reproduction, parts of the nuclei of two adjoining cells become exchanged, so that the first cell has part of the nucleus of the second cell and the second cell has part of the nucleus of the first cell. This is known as conjugation.

Conclusion. — 1. How do paramœcia reproduce?

2. What is the difference between fission and conjugation?

Problem 113: Comparative study of various forms of single-celled animals to explain division of labor. (Extra Problem.)

Materials. — Figures on opposite page showing amœba, paramœcium, vorticella, and a colonial form, such as charchesium or zoöthamnium.

Observations. — Examine the figure of an amœba. Are there any special structures for locomotion? The entire cell body changes shape as the animal moves. Has the animal any definite mouth? Gullet? Look at the figures. How is food taken into the body? Look for food vacuoles, contractile vacuoles, nucleus.

Compare an amœba with a paramœcium. In which cell is the work performed by more separate parts of the cell?

NOTE. — The performance of different kinds of work by different structures in a plant or animal is called *division of labor*.

Compare the amœba and paramœcium with vorticella. Note the stalk; it is contractile. Is the entire body covered with cilia? Are the cilia used for the same purpose as in paramœcium? Is there a definite food opening? How does food get into this opening? (Demonstration of a vorticella in a weak carmine mixture will show this point.)

Look at the colonial form. How does it differ from vorticella? How does it move? How is food obtained? Is there greater or less division of labor than in a single cell?

Conclusion. — What is division of labor? Explain from comparison with at least three one-celled animals.

Problem Questions

1. Explain the term "reaction to stimuli" with reference to paramœcium.
2. What parts of a cell are found in paramœcium?
3. How does paramœcium move? Feed? Breathe? Reproduce?
4. How is division of labor illustrated among the Protozoa?

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XIV. DIVISION OF LABOR. THE VARIOUS FORMS OF PLANTS AND ANIMALS

Problems. — *The development and forms of plants.*

The development of a simple animal.

What is division of labor? In what does it result?

How to know the chief characters of some great animal groups.

Laboratory Suggestions

A visit to a botanical garden or laboratory demonstration. — Some of the forms of plant life. Review of essential facts in development of bean or corn embryo.

Demonstration. — Charts or models showing the development of a many-celled animal from egg through gastrula stage.

Demonstration. — Types which illustrate increasing complexity of body form and division of labor.

Museum trip. — To afford pupil a means of identification of examples of principal phyla. This should be preceded by objective demonstration work in school laboratory.

To the Teacher. — The object of this chapter is to give the pupil a bird's-eye view of the plant and animal kingdoms. This is not done for the sake of accurate classification, but simply to impress him with the wonderful diversity and complexity of form and structure in the living world about him. Also these exercises should bring home the idea that division of labor and complexity of structure in plants and animals go hand in hand. The exercise in determining the place of animals and plants in the evolutionary scale should be largely an exercise in determining the amount of division of labor shown in a given group. It is needless to say that the work can best be done by means of type collections in a museum or in the laboratory. The outline (Problem 118) in the hands of the pupils aids in the identification of the various phyla. Comparison of type forms under these phyla gives the pupil an excellent opportunity for study of relation of forms.

Problem 114: *How the plant kingdom is classified.*

Materials. — Specimens of algæ, fungi, mosses, ferns, and flowering plants.

Note. — All animal and plant life shows greater or less division of labor, the more complex forms showing greater division of labor. We classify as *higher* the plants or animals showing greater division of labor.

a. Algæ

Method and Observations. — Examine some pond scum with a hand lens. What kind of body has the plant? Has it any root, stem, and leaves? Look at specimens under the microscope and on the chart to determine the methods of reproduction.

Conclusion. — 1. Would such a plant as this have much division of labor? Many different organs?

2. How does such a plant reproduce?

b. Fungi

Method and Observations. — You have already studied a yeast and a mold as examples of fungi. Study in addition a shelf fungus. Remember that the shelf-like part is the reproductive portion (much like the sporangium and stalk of black mold). Study a piece of decayed wood containing mycelium of bracket fungus. What is its general appearance? Compare with mycelium of mold.

Conclusion. — Is division of labor greater in the algæ studied or in the fungi studied? Explain fully.

c. Mosses

Method and Observations. — Notice that the body of the moss shows rootlike structures, *rhizoids;* an upright stem; and leaf-like structures. Notice that some bear stalks with a little capsule on the top. The stalk and capsule bear asexual spores and are known as the asexual generation. The moss plants produce egg and sperm cells in different organs, giving the title of sexual generation to this part of the plant.

Conclusion. — Does the separating of the plant into two phases, a sexual and an asexual phase, result in greater or less division of labor? Explain.

d. Ferns

Method and Observations. — The fern plant has roots, an underground stem, and large leaves called *fronds.* On the backs of some of the fronds are found asexual spore-producing bodies, *sporangia.* The sexual part of the fern (see chart) is a very tiny body called a *prothallus.*

Conclusion. — Compare the ferns with other plants in complexity of structure.

e. Flowering Plants

Method and Observations. — In the flowering plants the sexual generation is reduced to a very small part of the flower, the stamens and pistil. What structures found therein make this the sexual generation? All the rest of a plant — root, stem, leaves — is the asexual generation.

Conclusion. — 1. Compare the various structures of a flowering plant with those of the fern, moss, fungus, and alga.

2. Show that division of labor is greatest in the flowering plant.

f. Physiological Development

Refer back to your work on the function of the flower. At the time of fertilization, how many cells make up the young plant? What happens to it as it grows into an embryo? Is an embryo a more complex structure than an egg? Why? In the above forms is the development of this young plant in any way similar? (See charts or text figures.)

General Conclusion. — 1. What group of plants studied has the most complex structure? The greatest division of labor?

2. Is there any connection between the position of a plant in the plant kingdom and its complexity of structure? Explain.

***Problem 115**: To compare reproduction in plants with that in animals.*

Materials. — Charts and models illustrating processes of fertilization and development in plants and animals.

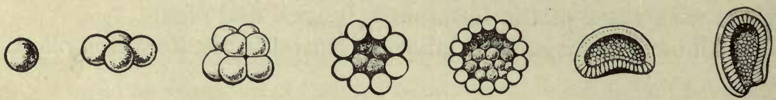
Method. — Compare, by means of charts, fertilization in several types of plants with that in some simple animal. Use models illustrating early development of amphioxus, fish, and frog.

Observations. — How does fertilization take place in a flowering plant? In a fern? In a moss? In a very simple plant? By what means does the sperm cell get to the egg cell in each of the above cases? Is there any outside agency that helps in this?

NOTE. — In animals, as in plants, two cells, the sperm and the egg, unite to form a fertilized egg. This cell will, under favorable conditions, develop into a new animal.

In animals, which is the larger, sperm or egg cell? Which is the movable cell? Suppose an animal, as a fish, laid its eggs in the water, how might fertilization take place?

NOTE. — The embryo of a plant (*e.g.*, the bean seed) grows as the result of the division of the original fertilized egg into first two, then four, then eight, etc., cells. An animal embryo develops in a similar manner.



Arrange models in order to show development from a single cell (the fertilized egg) to a hollow ball of cells, called the *blastula* stage. (See figures above.) Note what happens next in development. The cup-like structure is called a *gastrula*. How is the gastrula stage formed?

NOTE. — Most animals, including man, pass through the stages shown above.

Suppose that all the cells had cilia in the blastula stage. How would locomotion take place? Suppose the hollow of the gastrula is used as a food tube. Is there then any division of labor?

Conclusion. — 1. In what respects is fertilization similar in plants and in animals?

2. What stages of development are alike in all animals?

***Problem 116**: To study the division of labor in tissues and organs.*

Materials. — Charts and slides showing different kinds of tissues, microscope.

Method and Observations. — We have already found that cells having the same structure and performing the same work form *tissues*. Examples in our bodies are muscle tissue, nerve tissue, connective tissue, etc. Does a blastula have more than one tissue? A gastrula? Give reasons for your answers.

Examine figure, page 179, *Civic Biology*, or slides showing different

kinds of cells, such as muscle, nerve, and bone. Why do we have *different* tissues in a plant or in an animal?

NOTE. — The hand is an organ, a structure made up of different tissues, all of which work together for the performance of certain work.

Name some organ found in an animal; in a plant. Name some tissues that make up your hand; your foot; your eye. (Use your *Civic Biology*, pages 266–271, for this purpose.)

Conclusion. — 1. Why are cells of different shapes and sizes?

2. Of what purpose are tissues in our body?

3. Why are *organs* composed of tissues? Use the term *division of labor* in writing your answer.

Problem 117: *To find some of the functions common to all animals.*

Method. — Review the needs of a single-celled animal. What must a single-celled animal do in order to live?

NOTE. — Remember that food must be obtained, digested, and oxidized to release energy (in a many-celled animal this food must be circulated about the animal). Some of it must be made into living matter, and wastes must be excreted from the body.

What organs has a single-celled animal that perform each of these functions? Compare the needs of a paramœcium with *our* needs. Compare the functions of a paramœcium with our functions. Compare, in each, the organs which perform these functions so far as you know them. Get assistance from your textbook (*Civic Biology*, pages 180, 181).

Conclusion. — How does a single-celled animal compare with a very complex animal in the number of functions and in the organs it has for performing these functions?

Problem 118: *How to know some types of animals in the animal kingdom.*

Materials. — Dried or formalin specimens of sponge, sea anemone, starfish, segmented worms, crustaceans, insects, mollusks, and vertebrates (fish, frog, turtle, bird, and mammal).

Groups of Animals

NOTE. — Animals may be arranged in an evolutionary series beginning with simple forms and ending with very complex forms, such as man. Division of labor in a steadily increasing degree is seen as we go from the simple to the higher forms. We shall try to arrange the forms given in an *evolutionary* series, beginning with the simplest forms and working up to the most complex.

a. Protozoa

First would come one-celled animals, *Protozoa.* Name three Protozoa which you have studied.

b. Porifera

Sponges, *Porifera* (containing pores). Examples: bath sponge, *Grantia.* Simple fixed forms. Note a specimen of the bath sponge. Has it a skeleton? What is the internal structure of a sponge? (See figure on page 180, *Civic Biology.*)

c. Cœlenterates

Cœlenterates (*Cœlom* = body cavity, *enteron* = food tube). Examples: Hydra, sea anemone, jellyfish. There is a single cavity in the body with one opening. (See figure on page 179, *Civic Biology.*) The animals in this group are provided with stinging cells.

d. Segmented Worms

Examples: sandworm, earthworm. Long jointed or segmented animals with or without jointed legs. Nervous system on the under side of the body. (Pages 183, 184, *Civic Biology*)

e. Echinoderms

Examples: starfish, sea urchin. These animals have spines in the skin, body organs more complicated. (Pages 184, 185, *Civic Biology.*)

f. Arthropods

Having jointed body, jointed appendages, and outside skeleton. Nervous system on under side of the body. There are two great groups of these animals:

(*a*) *Crustacea.* Limy skeleton, segmented, body divided into two regions, more than three pairs of walking appendages, breathe through gills. Examples: crayfish, crab, lobster.

(*b*) *Insecta.* Having a horny skeleton (chitin), only three pairs of walking legs, breathe through tracheæ. Examples: bee, ant, grasshopper. Two smaller groups of Arthropods are also found: the *Arachnids*, spiders, having four pairs of legs, and the *Myriapods*, "thousand leggers," which have many pairs of similar jointed legs. (Page 185, *Civic Biology*.)

g. Mollusks

Examples: clam, snail, oyster. Have a soft, unjointed body, usually covered with a hard limy shell of one or two pieces (valves). This shell is formed by a covering called the mantle. These animals breathe through gills. (Page 185, *Civic Biology*.)

h. Vertebrates

Examples: fish, frog, turtle, bird, dog. Having an internal limy skeleton composed of pieces of bone jointed together. Also an external skeleton which may be scales, bone, feathers, nails, or hair. Breathe by gills or lungs. Central nervous system on back or dorsal side of body protected by a chain of bones called the vertebral column. (Pages 185–192, *Civic Biology*.)

Method and Observations. — Using the above directions pick out of the material given you one specimen of each group and arrange the specimens selected in a series showing evolutionary order.

Conclusion. — 1. What do you mean by evolutionary order? 2. Has division of labor anything to do with your placing these specimens as you have?

Problem Questions

1. Why do we speak of the plant or animal *kingdom?*
2. What results from fertilization in both plants and animals?
3. How are egg cells protected in birds? In a flower? Why should they be protected?

4. How does nature make up for lack of protection of the eggs of fishes? (See *Civic Biology*, pages 238–239.)

5. What is division of labor?

6. What is a blastula? A gastrula? An embryo? Give examples.

7. What is a tissue? An organ?

8. What are the functions necessary for all animals?

9. How are these functions performed in a single-celled animal? In a many-celled animal?

10. What do we mean by evolutionary order?

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Wright, *Four-footed Americans*. The Macmillan Company.

XV. THE ECONOMIC IMPORTANCE OF ANIMALS

Problems.* — *I. *To determine the uses of animals.*
(*a*) *Indirectly as food.*
(*b*) *Directly as food.*
(*c*) *As domesticated animals.*
(*d*) *For clothing.*
(*e*) *Other direct economic uses.*
(*f*) *Destruction of harmful plants and animals.*

II. *To determine the harm done by animals.*
(*a*) *Animals destructive to those used for food.*
(*b*) *Animals harmful to crops and gardens.*
(*c*) *Animals harmful to fruit and forest trees.*
(*d*) *Animals destructive to stored food or clothing.*
(*e*) *Animals indirectly or directly responsible for disease.*

To the Teacher. — Inasmuch as this work is planned for the winter months the laboratory side must be largely museum and reference work. It is to be expected that the teacher will wish to refer to much of this work at the time work is done on a given group. But it is pedagogically desirable that the work as planned should be *varied.* Interest is thus held. Outlines prepared by the teacher to be filled in by the student are desirable because they lead the pupil to individual selection of what seems to *him* as important material. Opportunity should be given for laboratory exercises based on original sources. The pupils should be made to use reports of the U. S. Department of Agriculture, the Biological Survey, various state reports, and others.

Special home laboratory reports may be well made at this time, for example: determination at a local fish market of the fish that are cheap and fresh at a given time. Have the students give reasons for this. Study conditions in the meat market in a similar manner. Other local food conditions may also be studied first hand.

This chapter is intended to be a practical résumé of the use and harm done by animals. Some of the work is intended as a change from pure laboratory work to that of reference reading. But some extremely important work outlined in this chapter should be taken when the season will allow, in the laboratory, in the field, or at home. Practical work on the relation of mosquitoes and flies to disease should be part of every educated person's knowledge, for ability to deal with these pests may mean health as well as comfort in the home locality.

Problem 119: What animal foods are cheapest in any locality and why? (Home work.)

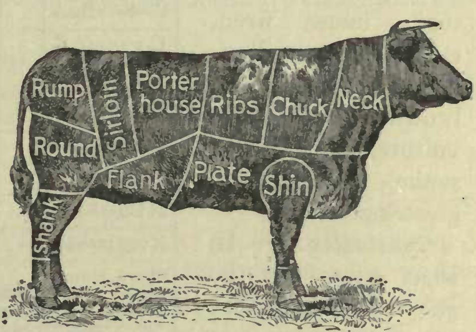
Method and Observations. — *a.* Visit your local fish and meat markets. If in New York, read the publications of the Mayor's Food Supply Committee. Make tables of the fish and meats that

Name of Fish	Habitat	Price per lb.	Remarks
1.			
2.			
etc.			

Name of Meat	Animal it Comes from	Habitat	Cut or Part Eaten	Cost per lb	Remarks

are relatively cheap and those that are expensive. Go to the library and look up in an encyclopedia or Jordan and Evermann's *American Food and Game Fishes* the habitat of each fish you have priced. In Hornaday's *American Natural History* or an encyclopedia look up the habitat of the animals which supply the meats you have priced. Read Kipling's *Captains Courageous* to see how certain fish are obtained.

b. Using the figure, locate the various cuts of meat priced at the market. You will find that the cut of meat (part of animal used) determines the price, and this price is further determined by the demand of people buying and the supply in the market.



Conclusion. — 1. Does the habitat of the animal have anything to do with its price in the market?

2. What other factors might influence the price of fish? Ask your teacher to help you in this.

3. What factors might determine the price of meat?

4. What factors largely determine the price of cuts of meat?

***Problem 120**: How animals may benefit mankind.*

Materials.—Hunter's *Civic Biology*, pages 197–231, Toothaker's *Commercial Raw Materials*, Government and State Department reports of various kinds. A visit to a commercial museum.

Habitat	Use of Products	Preparation of Products	Other Facts

Method. — Using your sources of information, make out in tabular form a report giving (1) habitat, (2) use, (3) preparation of product, (4) other interesting facts with reference to the following animals: cow, sheep, horse, pig, whale, walrus, honeybee, ichneumon fly, silkworm, ladybug, tachina fly, gall insects, blister beetles, lac insect, cochineal, bumblebee, carrion beetle, toad, house wren, cuckoo, bank swallow, bluebird, woodpecker, brown thrush, gull, vulture, owl, black snake, milk snake, green snake.

Conclusion. — In what ways are the above animals useful to man?

	Insects	Grains	Fruits	Weed Seed	Rodents	Fishes	Miscel.
Bobolink							
Blackbird							
Catbird							
Coopers Hawk							
Crow							
Cuckoo							
Dove							
English Sparrow							
Gull							
Kingbird							
Kingfisher							
Owl, Horned							
Phoebe							
Quail							
Robin							
Sapsucker							
Starling							
Swallow							
Thrush							
Wren							

***Problem 121**: To find out how birds are of economic importance.*

Materials. — Pamphlets of the Depart-

ment of Agriculture (see list of Reference Books) and *Civic Biology*, pages 209–211.

Method and Observations. — Fill out the preceding table on the food of some birds, using references suggested above.

Conclusion. — Which of the birds are of use to man? Of harm? Which may be of both harm and use? Explain your answers.

Problem 122: *What are the causes of decrease in the number of birds?*

Method and Observations. — Using your own experience and the information obtained from Hornaday's *Our Vanishing Wild Life*, complete a table like the accompanying.

Factors	Birds Affected	How Affected	Remedies Proposed
Clearing of Forests			
Cultivation of Land			
Slaughter for Game			
Slaughter for Feathers			
Egg Collecting by Boys			
Use as Food			
Cats, Weasels, etc.			
Sparrows, Jays, etc			

Conclusion. — In a carefully written paragraph suggest some methods of preventing the decrease of our helpful birds.

Problem 123: *To study the life history of the mosquito.*

NOTE. — There are four distinct stages in the development of the mosquito: egg, larva, pupa, and adult. These will be taken up and studied in order.

a. The Egg

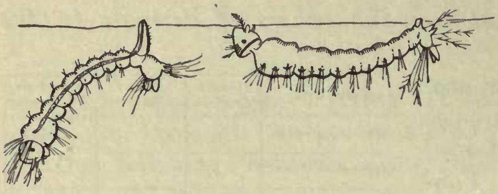
Method. — The eggs of mosquitoes are laid on the surface of still salt or fresh water pools from April to October. By placing a can of water in a lot, we can often obtain the small rafts of eggs of the common mosquito, the *culex*, and less often the single floating eggs of the malarial mosquito, the *anopheles*.

Any standing water, especially in barrels, old cans, neglected drains, catch basins, and swamps, may make a near-by neighborhood almost uninhabitable. The yellow-fever mosquito, *stegomyia*, is not found in the North but is found in the warmer parts of the United States.

b. The Larva (Wiggler)

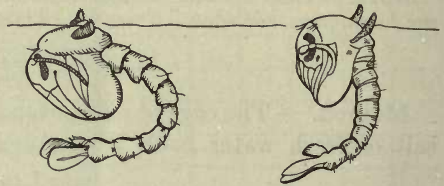
Materials. — The eggs will hatch if kept in a warm place, or wigglers can be scooped from a pond or pool of water. These may be kept in a screened battery jar half full of water.

Observations. — What is the shape of the larvæ? How do they move through the water? Watch the larvæ while at the surface. Which end is up? (Note the breathing tube that reaches through the surface of the water.) What is the position of the larvæ while at the surface? If they lie horizontal to the surface, they are the larvæ of the *anopheles*, the malarial mosquito; if at an acute angle, the larvæ are those of *culex*, the harmless mosquito.



c. The Pupa

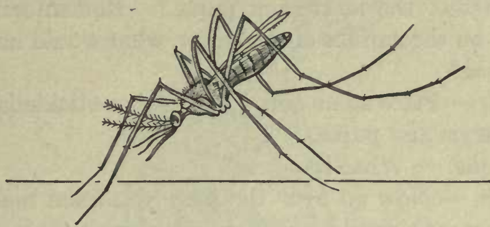
Method and Observations. — Place a number of wigglers in a screened battery jar. Allow them to cast off their skins and become pupæ. How does this stage differ from the larval stage? Notice the empty shells of the pupæ floating on the surface of the water. How did the adult mosquitoes get out? Do the pupæ come to the surface of the water? If so, why? Compare the position of the pupæ at rest with the figures. Is the mosquito a *culex* or an *anopheles?*

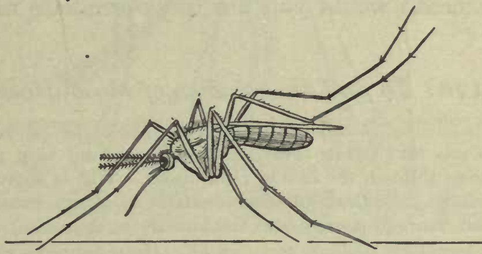


d. The Adult

Observations. — In a hatched adult observe the number and kind of wings. In which insect group do mosquitoes belong? Notice the antennæ or feelers. (The males have more bushy

feelers. Males do not bite.) What is the resting position of the adult? Compare with the figures on page 218, *Civic Biology*, and decide what kind of mosquito it is.





Conclusion. — Write in a concise paragraph a short life history of the mosquito, either culex or anopheles.

Problem 124: *To find the breeding places of mosquitoes in any locality and how to destroy them.*

Field Trip. — Plot a map of your district showing all the water that might contain mosquito larvæ. Remember that tin cans in rubbish heaps, flat tin roofs or gutters, anything that can hold water for two weeks at a time may breed mosquitoes. Look carefully for larvæ or pupæ. On the map note with a cross where you have found them. If such localities are found, go to the householder and explain what you have found.

Conclusion. — If mosquitoes can fly several hundred yards from their breeding places, is my home safe from mosquitoes?

Problem 125: *To determine some methods of destroying mosquitoes.*

Materials. — Mosquito larvæ and pupæ, battery jar, kerosene oil, goldfish.

Method 1. — Put a few mosquito larvæ and pupæ in a small battery jar. Pour in a few drops of kerosene oil.

Observations. — What happens to the oil and the water? What becomes of the larvæ and pupæ? Remembering that all eggs are laid on the surface of the water, what would happen to the eggs when laid?

Method 2. — Place some small goldfish or sticklebacks in a jar containing larvæ and pupæ.

Observations. — What happens?

Conclusion. — Now go over the map you have made. Which of the above means would you use to exterminate mosquitoes in your locality?

Problem 126: *To find the relation of mosquitoes to diseases of man.*

NOTE. — Malaria and yellow fever, diseases caused by tiny protozoans, are transmitted to man through the bite of mosquitoes. This is proved because men have escaped malaria in malaria-infected districts by taking precautions to have their bodies at all times protected from the bite of the mosquito. This was done by screening, by remaining indoors at times when the mosquitoes were out, and by wearing, when exposed, head nets and gloves.

In 1890 two London doctors allowed themselves to be bitten by anopheles mosquitoes which had previously bitten people who had malaria. In a little over two weeks both came down with malaria.

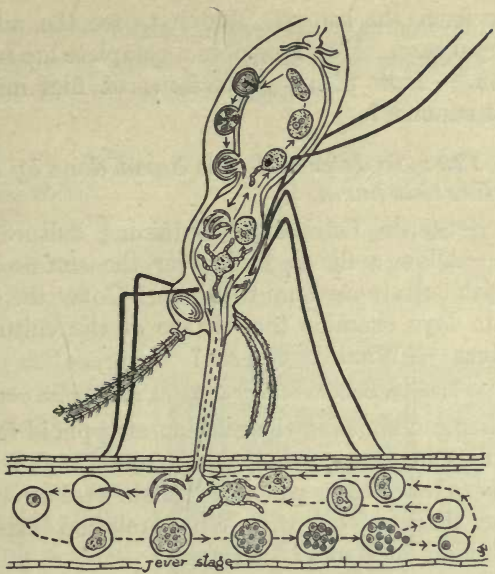
Observations. — What causes malaria? What have swamps and stagnant water to do with malaria? Why did the people who were screened not get malaria? Why did the London doctors get malaria?

Conclusion. — What has the anopheles mosquito to do with malaria?

Problem 127: *To study the life history of the parasite causing malaria.*

Material. — Charts, or illustration in Hunter's *Civic Biology*, page 217.

Observations. — Note the lower part of the diagram which represents the blood tube of a man. What changes take place in the parasite within the corpuscles? What two kinds of organisms ultimately are formed?



Notice that the malarial parasite passes part of its life history in the body of the mosquito, and part in the human body. The lower part of the figure represents a blood vessel in man. The parasites live part of their lives in the blood corpuscles. Then they multiply and break out of the corpuscles. (See right side of figure.) Using this figure and information from your *Civic Biology*, work out the complete life history of the malarial parasite.

What happens if these organisms are taken into the mosquito's body?

NOTE. — Only when both forms of cells are taken into the body of the mosquito are the parasites able to continue their development there.

Conclusion. — How might malaria be transmitted?

Problem 128: *To study the life history of the typhoid fly.*

Materials. — Raw meat, glass dishes.

Method. — Expose pieces of raw beef where flies will light on them. After a few hours cover in glass dishes or small battery jars with screen covers.

Observations. — Watch the meat. In pieces on which eggs were laid by the flies describe the stages of development as they appear. Do the larvæ grow any? They are called *maggots*. How do the

pupæ differ from the larvæ? Watch to see the adults emerge from the pupal case. How long does a complete life history take?

Conclusion. — How many generations of flies might develop during a hot summer?

***Problem 129:** To determine the harm done by the fly and the way it does this harm.*

Material. — Sterile Petri dish containing culture medium.

Method. — Allow a fly to walk over the surface of a sterile Petri dish with culture medium within it. Cover the dish. After three or four days examine the surface of the culture medium.

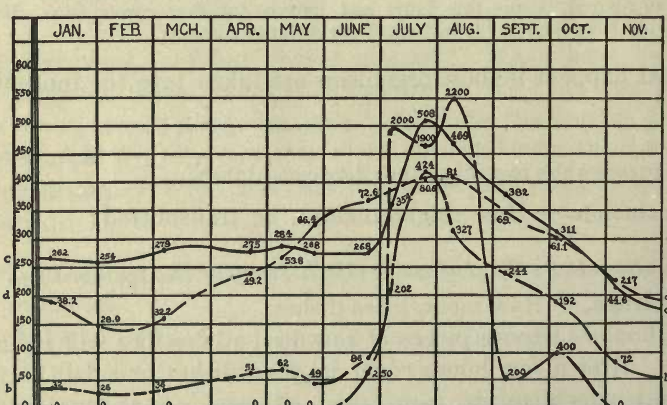
Observations. — What do you see?

NOTE. — Flies breed in manure, filth of all kinds, and human excrement as well.

Study a diagram showing the relation of typhoid fever to open toilets and flies in Jacksonville, Fla. (page 224, *Civic Biology*). Why were there fewer cases when the toilets were screened?

Study the diagram below. What relation exists between diarrheal diseases and flies? Explain.

Examine the foot of a fly under the compound microscope or study upper figure, page 223, *Civic Biology*. What adaptations for carrying germs do you find?



INFANT MORTALITY CURVE.

a, prevalence of flies; *b*, diarrheal under five years; *c*, deaths under one year; *d*, mean temperature.

Conclusion. — 1. What diseases may be carried by flies?

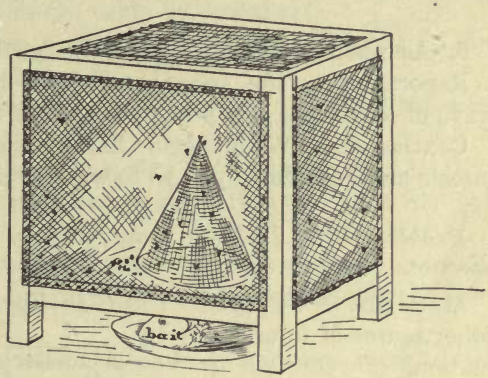
2. Where do they get the germs of these diseases?

3. How do they carry these diseases?

Problem 130:* *What is the best way to catch and destroy flies? (Home Work.)

Materials. — Flytrap, tin plate, carbolic acid, and insect powder.

Method and Observations. — Make a flytrap according to the plan shown; bait it with stale fish or other food. Leave it for one day, then plunge it into boiling water and count the number of flies which you caught.



AN EASILY MADE FLYTRAP.

Heat a tin plate containing strong carbolic acid so that the fumes will fill a room (*e.g.*, the kitchen) containing a number of flies. What results? How does it compare with your trap?

Burn a few ounces of insect powder in a pan in the same room on another day. Compare your results with those above.

Conclusion. — 1. Which is the best method of those given for destroying flies in your home?

2. Knowing when and where flies breed, when would be the best time to "swat the fly"? How would this method compare with other ways of extermination studied?

Problem 131:* *To determine harm done by insects.

Materials. — Trips to museum, reference to texts, and various bulletins of the Department of Agriculture.

Observations. — Make out in the form of the following table a report on the harm done by insects:

1. To gardens. — Report on cutworm, corn worm, potato beetle, squash bug.
2. To crops. — Boll weevil, chinch bug, plant lice, Hessian fly.
3. To fruit and forest trees. — Codling moth, gypsy moth, tussock moth, hickory borer, maple borer, scale insect.
4. To stored food. —Weevils, roach, ant.
5. To clothes, etc. —Clothes moth, roach.

Name	Harm done	Stage when it does harm	How fight the pest

6. As disease carriers. — Flies, mosquitoes, fleas, bedbugs.

Report, using the above sources of information, on specific ways of combating one pest from each of the above groups.

Conclusion. — What specific harm is done by the above-named insects and how would you go to work to prevent this harm?

Problem 132: *To know some forms of animal life that cause disease.*

Materials. — Use your *Civic Biology,* Chap. XV, or any other source of information.

Observations. — Fill in the accompanying chart, giving information with reference to disease-causing animals, especially hookworm, trichina, and tapeworm.

Name of Disease	Disease Caused by	Disease Carried by	How to fight Cause	How to fight Carrier
Bubonic Plague				
Hookworm				
Kala Azar				
Leprosy				
Malaria				
Rabies				
Sleeping Sickness				
Small Pox				
Tapeworm				
Texas Fever				
Trichinosis				
Typhoid				
Yellow Fever				

Conclusion. — 1. What animals *cause* disease and what diseases do they cause?

2. How would you attempt to cure any three of these diseases?

3. How would you attempt to prevent any three of these diseases?

Problem Questions

1. How long does it take for one generation of flies to develop?
2. During what part of the year are flies most abundant? Why?
3. During the Spanish-American War flies were more deadly than Spanish bullets. Explain.
4. What diseases may be carried by flies?
5. What relation has the garbage pail to the typhoid fly? Explain.
6. Why should food exposed for public sale be kept covered?
7. Why should food on the table be screened?
8. What dangers come from open spittoons and what do flies have to do with this danger?
9. Why should garbage pails be frequently sprinkled with slaked lime or kerosene?
10. Why the cry in the *early* spring — "Swat the fly"?
11. What harm do mosquitoes do? How do they do this harm?
12. What are the natural enemies of the mosquito?
13. How would you go to work to rid your neighborhood of mosquitoes?
14. How would you tell harmful from harmless mosquitoes?

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XVI. THE FISH AND FROG, AN INTRODUCTORY STUDY OF VERTEBRATES

***Problems.** — To determine how a fish and a frog are fitted for the life they lead.*

To determine some methods of development in vertebrate animals.

(*a*) *Fishes.*
(*b*) *Frogs.*
(*c*) *Other animals.*

Laboratory Suggestions

Laboratory exercise. — Study of a living fish — adaptations for protection, locomotion, food getting, etc.

Laboratory demonstration. — The development of the fish or frog egg.

Visit to the aquarium. — Study of adaptations, economic uses of fishes, artificial propagation of fishes.

To the Teacher. — This chapter is intended to introduce the student to the life history, structure, and adaptations found in a vertebrate, the fish or frog. If time permits, both forms may be used, but the writer has found that for use in the early spring (which would be the logical time for this exercise if the course was begun in the fall) the frog is a more useful form because of its superficial similarity to the structure of man and because of the ease with which developmental material may be obtained.

The fish, however, as a living specimen for laboratory use is excellent, especially for the study of adaptations. The concept of a structural adaptation is extremely difficult for a pupil beginning, and considerable drill should be given in an attempt to fasten the concept. Field or aquarium trips may be made to form an important part of this work, thus adding interest through varied work.

***Problem 133:** To determine how a live fish is fitted for life.*

Materials. — Small battery jar with small living fish such as goldfish, bream, or minnows.

a. Locomotion

Observations. — Note adaptations for locomotion. How is the body of the fish fitted for life in the water? Mention three dif-

ferent adaptations. Watch the fish carefully and locate its organs for movement. How many single fins are there? How many paired fins?

NOTE. — Fins on the upper side of the body are called *dorsal fins*, the tail fin is called the *caudal fin*, and the single fin on the lower side is the *anal fin*. The front paired fins are called the *pectoral fins*, while those just below and behind are called the *pelvic fins*.

Try to discover the use in movement of each of the above-named fins.

Conclusion. — 1. How does a fish move? Watch the fish swimming and try to decide what fins are used in moving forward, in turning, in moving backwards. Note whether the *body* is used in locomotion.

2. Tell just how any particular fin is adapted or fitted to do its work. (Remember you must show how a *structure* is especially designed to do a *particular* work.)

3. How is the body fitted for life in the water?

b. Protection

Method. — Examine carefully a preserved specimen.

Observations. — What structures do you find on the surface of the body? How are these structures placed with reference to each other? Feel the body of the fish. What adaptation for protection exists here? Note the color both above and below. Remembering that many of the enemies of the fish are below him and some above, explain how the animal receives protection from its color.

Conclusion. — What are the principal adaptations for protection in the fish?

c. Breathing

Method. — Look at the fish carefully and observe the movements of the mouth.

Observations. — What is the relation of the movement of the mouth to that of the *operculum*, the flap which covers the gills? Note position and color of the gills. What gives them this color? Introduce a few grains of carmine in the water in front of the mouth of the fish. Trace the course of the carmine. Where does it

come out? What gas is in the water? How might the fish use this gas? How might this gas come in contact with the gills?

Conclusion. — Tell just how a fish breathes, writing a paragraph in explanation and illustrating with a diagram.

Problem 134: To study food getting by the fish.

Material. — Live fish.

Method. — Watch the fish to see if it will eat. Remember what you know about catching fish.

Observations. — Do fish see or are they made aware of the presence of food by other means? Do fish have teeth? Do they chew their food? Give uses of teeth. How does the fish's means of obtaining food compare with ours?

Conclusion. — Write a paragraph telling how a fish gets its food.

Problem 135: To study the sense organs of the fish.

Material. — Specimens of fish.

Method. — Study the external sense organs of the fish. What are they?

Observations. — What shape are the eyes? Does a fish move its eyes? Describe any movement. A fish is very nearsighted owing to the shape of the eye. Find two nostril holes. These lead to little pits in which are located the nerves of smell. Does a fish breathe through its nose? Find a distinct line running down the side of the fish. This is called the *lateral line* and contains organs of sense. The ears of the fish are out of sight in the head and are largely used for balancing.

Conclusion. — Write a paragraph telling how the fish is fitted with sense organs. Compare its vision, sense of smell, and power of hearing with your own in respect to keenness.

Drawing. — Make a side view of a fish. Label all the structures we have discussed.

Problem 136: To study some of the internal organs of a fish.

Material. — Preserved specimens with under body wall cut away.

Observations. — Push a blowpipe down the gullet, into the baglike *stomach*. Then follow the folded *intestine* until it reaches the anus or vent, where the solid waste leaves the body. Find, partly covering the stomach, a large lobed gland, the *liver*. Just above the stomach you will find the *ovary* or *spermary*, depending on the sex of fish (female or male). Still more dorsal, find a glistening, thin-walled sac, filled with gases, the *air bladder*. Close to the backbone will be found the dark red *kidney*. Make a drawing to show all of these organs in natural position. The heart is found just in front of the stomach. Study it carefully, comparing it with the figure on page 235, *Civic Biology*. Make out its connection with the gills, the red structure on each side of the fish's head. What use has the heart? The gills? Why should blood be sent to the gills? Study a chart of the circulation of a fish to see where blood comes from as it goes to the heart and where it goes to after leaving the gills.

The complete round of the blood from the heart back to the heart makes up the circulation of blood in the fish.

Conclusion. — 1. What are the various systems within the body cavity of the fish?

2. What do you understand by the circulatory system?

Problem 137: *To study the skeleton and central nervous system of the fish.* (Extra.)

Material. — Use prepared skeleton or chart.

Observations. — Notice the column of bones extending from the head into the tail of the fish. This is called the *vertebral column*, or *backbone*. Of what advantage to the fish is a series of bones over one bone?

NOTE. — The central nervous system, consisting of the brain and spinal cord, lies inside this chain of bones. To this central system nerves pass in from the outside of the body, bringing sensations, while other nerves pass outward to muscles, causing movement.

Conclusion. — 1. What are the uses of the skeleton to the fish?

2. Why is it made of many bones?

3. Are there any other bones in the fish? Where are they located?

4. How is the nervous system protected?

***Problem 138:** How fishes are artificially propagated.*

Method. — The operations of *stripping* can be demonstrated in the classroom at certain times of the year, or if the school is in the neighborhood of state or government fish hatcheries,[1] visit them. Make careful notes on the artificial methods of raising fishes. Observe especially the equipment of the hatchery tanks, caretaking of fish, etc. (See page 240, *Civic Biology*.)

Observations. — Note the *stripping* of the females for roe (eggs) and the males for milt (sperms). Collect and examine roe and milt under the compound microscope. Which cells are larger, roe or milt? Which are the more active? Why?

Why are the eggs squeezed into a bucket with fresh water and the milt immediately poured over them?

Why are the eggs then placed in receptacles which have water running through them?

NOTE. — Fresh-water fishes usually lay their eggs on the bottom of brooks or rivers, sometimes in nests prepared for this purpose. After the eggs are laid the male sprays them with milt.

In what respects does artificial fertilization resemble this process?

Conclusion. — 1. Write a paragraph on the process of artificial fertilization in fishes.

2. Which would be a surer method of fertilization, artificial or natural? Explain.

3. Of what value is artificial propagation of fishes?

***Problem 139:** Trip to the aquarium.* (Optional, in place of Problems 133 and 138.)

Method and Observations.— Select a lively fish.

Is the fish protected by form or color? If so, explain how. Show exactly what each fin does for the fish in the process of locomotion. Can a fish see? Hear? Smell? Give reasons based on your observations. Explain exactly how a fish gets its oxygen in breathing. Make a diagram in your notebook to illustrate

[1] In place of hatcheries, study figures of the process, for salmon or trout. See a Manual of Fish Culture, Department of U. S. Fish Commission for 1898, Plates 16, 28, 34, 53, especially for salmon and trout.

this. Extra credit will be given for any additional observations to show how the fish is fitted (adapted) to its surroundings.

Make three columns on your paper. Select ten fishes of economic importance. Place in the first column the name of each fish, in the second its habitat (where found), in the third its use to man.

Name of Fish	Habitat	Use to Man

Write a paragraph telling how these different fishes *actively* protect themselves and two ways in which fishes *are* protected. (By being like their surroundings is an example of the latter.) Give the name of the fish, and its habitat in each case.

Visit a hatchery and make careful notes telling,

(1) The method of fertilization of the egg.

(2) The kinds of eggs that are hatching.

(3) The apparatus used in hatching different fish. (Make diagrams to illustrate.)

(4) Methods of caring for young fish after they are hatched.

(5) Any other observations on the process and its general use to man.

Conclusion.— Write up your trip in an interesting manner. Illustrate it if possible, and hand it in to your instructor not later than two days after the trip.

***Problem 140**: To determine some adaptations in a living frog.*

Materials. — Live frogs, battery jars, charts.

Observations. — How does the shape of the frog fit it for life in the water? Note the color and markings. Feel the skin. In what respect is it an adaptation?

Conclusion. — Remembering where a frog lives, write a paragraph telling how the frog is fitted to its surroundings.

Problem 141: Adaptations of appendages for locomotion.

Observations. — Locate the appendages. How many do you find? What differences do you find between the fore and hind legs? What purposes do the hind legs serve? The fore legs?

Conclusion. — 1. Show exactly how the legs of the frog are fitted for locomotion.

2. Of what kind of locomotion is the frog capable?

Problem 142: Adaptations for sensation.

Observations. — Touch the frog gently (if possible without its seeing you). How does it respond? How is the eye fitted for its work (position, movement, etc.)? How is the eye protected? Touch it. Back of the eye find the eardrum. Describe it in size and position.

Conclusion. — What are the uses of each of the sense organs? Give experimental proof if possible.

Problem 143: Adaptations for food getting.

Method and Observations. — Open the mouth of a freshly killed frog and move the tongue. Compare with figure on page 242, *Civic Biology*. Feel both jaws to find whether the frog has teeth. Feel the roof of the mouth.

Conclusion. — Write a paragraph telling how the frog uses its tongue and teeth in catching its prey.

Problem 144: Adaptations for breathing.

Method. — Watch carefully the throat and sides of a frog that has its head out of water. Note the pulsations of the throat. Count the number of movements per minute.

Note that every so often another more noticeable movement occurs. What happens to the nostril holes when this movement takes place? Does this latter movement, when the nostril holes are closed, make the mouth cavity larger or smaller?

Examine a dissected specimen, or chart showing glottis, trachea, bronchial tube, and lungs. Insert a blowpipe in the glottis and inflate the lungs. Are they elastic?

Conclusion. — 1. Where must the air go when the frog makes a swallowing movement with the nostril flaps closed?

2. Write a paragraph comparing the breathing of the frog and of yourself.

Drawing. — Draw a side view of the living frog, natural position. Label all parts mentioned in the previous study.

Problem 145: Museum trip to study the frog group. (Extra Problem based on trip to American Museum of Natural History.)

The following suggestions might be modified for a field trip where such a trip is possible.

Method. — Begin work at one of the two groups on which questions follow. Read the labels in front of each group and learn all you can about what the group contains before you begin to answer the questions. Then answer the following questions, making the answers tell a connected story in your notebook. Ask questions of your teacher *only* when you cannot find the answer to a question yourself.

a. The Toad Group

What time of year does it seem to be? How do you know? What flowers are most abundant at this time in this locality? (Ask help from your teacher if you do not know them.) What animals are found living in the water? On the land or in the trees? Both on land and in the water? What are the latter animals called? (*Amphi* = both.)

Look for specimens of the tree frog (*hyla diversicolor*). Describe three different changes in color in these frogs. In what ways are these changes adaptations? Explain.

Describe where and when toads lay their eggs. Compare the egg masses of the toad with those of the frog. How are the eggs protected? What differences can you find between toad and frog tadpoles? (Examine preserved specimens.)

Enumerate all the enemies of a toad seen in this group and tell how the toad is fitted (adapted) to escape from each of these enemies.

Mention three structural adaptations found in a toad or frog

which fit it for the life it leads. Explain exactly how each structure you have described *is* an adaptation.

b. The Bullfrog Group

Show three ways not mentioned in the last question in which the bullfrog is fitted or adapted to its environment. At what time of year do frogs deposit their eggs? How does it compare with that of the toad? (See the toad group.) How do you account for the presence of the large tadpoles found swimming about?

What might be some of the enemies of the bullfrog? How might it escape from its enemies? Explain exactly how a frog catches an insect. Compare the habitat of the bullfrog with other amphibians found in the groups in this alcove. How is it similar and how does it differ?

Problem 146: *To collect and study frogs' eggs.*

Materials. — Trip to shallow fresh-water pond. Battery jars or aquarium.

Method. — Look for eggs in shallow fresh-water ponds late in March or early in April. Collect some eggs and place them in a shallow aquarium with some algæ in a sunny place.

Observations. — Notice that the eggs look like little black dots in a mass of jelly. Is their color uniform?

The collected eggs have probably been fertilized. They were laid in the water by the female ; the males fertilizing them by placing sperm cells on them, as soon as the eggs were laid. After laying, the thin albuminous coating with which they are covered swelled up and they stuck together.

Examine some of the eggs under a magnifying glass. Some of them have probably begun to *segment* (divide into many cells). Which side of the egg, the black or white side, seems to be broken into smaller cells?

NOTE. — The white side is filled with *yolk*, or food.

Conclusion. — Write a paragraph telling where frogs lay eggs, how the eggs are fertilized, and how they are protected after fertilization.

***Problem 147**: To study conditions favorable for development of frogs' eggs.*

Materials. — Live frogs' eggs, glass dishes.

a. Temperature

Method. — Place some eggs in shallow dishes. Place one lot in a moderately warm room, another in a cold room, and a third in an ice box.

Observations. — Watch and record results daily for two weeks.

Conclusion. — What is the relation between temperature and the development of frogs' eggs?

b. Oxygen

Method. — Place a *large number* of eggs in a dish containing one quart of water. Place a *few* eggs from the same egg mass in another dish containing a like amount of water. Place both dishes where they receive the same conditions of light and heat.

Observations. — Make and record operations daily for two weeks.

Conclusion. — 1. Which lot receives the more oxygen per egg? Explain.

2. Does oxygen affect the development of frogs' eggs?

***Problem 148**: To study the metamorphosis of the frog.*

Materials. — Wax models of development of frog, living or preserved specimens of various stages, charts, and young and old stages of tadpoles in shallow dishes.

Method and Observations. — Using the wax models, try to find the chief differences in the development of this egg as compared with the egg without any yolk. Can you find any gastrula stage here? Look at the model cut in section to answer this point. (See also page 245, *Civic Biology*.)

Trace the changes from the time the egg segments to the time it becomes a free-swimming tadpole. Where are the gills located at first? What kind of mouth parts does the tadpole seem to have? Notice the *sucker* and the horny *jaws*.

How would the early stage of the tadpole breathe? What sort of

food must it of necessity eat? Using the models, charts, and living specimens, now compare the later stages of the tadpole with those of its earliest life. Are external gills always present? If not, what becomes of them? Examine the internal gills in the older tadpoles. Also try to find out why some tadpoles seem to come to the surface of the water, swallow a bubble of air, and then go under the water again.

NOTE. — There is a stage in the life of the tadpole when it uses both gills and lungs in breathing.

At what stage of the metamorphosis does the tadpole breathe by internal gills? By both lungs and gills? Which grow first, the front or hind legs? What becomes of the tail? Are there any changes in the appearance of the mouth in an older tadpole? Are there teeth in the mouth of a tadpole? A frog?

Conclusion. — What changes take place during the life of the tadpole and how do these changes fit it for the life which it has to lead?

***Problem 149**: To work out a comparison of development of the vertebrates.*

Method. — Fill out a table like the accompanying.

	Fish	Frog	Bird	Mammal
Number of Eggs				
Protection of Eggs				
Care of Eggs				
Probability of Growth of Eggs				

Conclusion. — In which of the above animal groups do the eggs have the best likelihood of reaching development into adults? Explain your answer.

Problem Questions

1. What do we mean by adaptation to environment? Illustrate with certain organs in a fish; in a frog.
2. Might color be an adaptation? Give examples.
3. Might habits of life be adaptations or the results of adaptations? Explain.

4. Compare breathing in the fish, in the frog, and in your own body. What especial adaptation do you note?

5. Why do some fishes lay more eggs than others?

6. What have life habits of fishes to do with their possible extermination through overfishing?

7. What is artificial propagation of fishes?

8. Some kinds of fish eggs are provided with a minute drop of oil in each egg. Of what use might this be in the development of the egg?

9. Why are many more sperm cells manufactured than egg cells in a cod? Explain with reference to the egg-laying habits of the fish.

10. Name ten food fishes that are cheap in your locality; ten that are expensive. Why are they either cheap or expensive?

11. What are the *amphibia* and why are they so called?

12. How is a frog fitted to live in water? On land?

13. Do fishes and frogs lay their eggs at any especial time of year? Give examples.

14. How does the development of a frog differ from that of a fish?

15. Explain the term metamorphosis.

16. What are the chief enemies of the frog? How is it protected from these enemies?

17. How may frogs and toads be useful to man?

18. How are the eggs protected and from what enemies?

19. Of what use is the yolk of an egg in development?

Reference Books

Hunter, *Civic Biology*, Chap. XVI. American Book Company.
Hunter, *Elements of Biology*, Chaps. XXII, XXIII. American Book Company.
Hunter, *Essentials of Biology*, Chap. XXII. American Book Company.

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XVII. HEREDITY, VARIATION, PLANT AND ANIMAL BREEDING

Problems. — *To determine what makes the offspring of animals or plants tend to be like their parents.*

To determine what makes the offspring of animals and plants differ from their parents.

To learn about some methods of plant and animal breeding.

(*a*) *By selection.*

(*b*) *By hybridizing.*

(*c*) *By other methods.*

To learn about some methods of improving the human race.

(*a*) *By eugenics.*

(*b*) *By euthenics.*

Suggestions for Laboratory Work

Laboratory exercise. — On variation and heredity among members of a class in the schoolroom.

Laboratory exercise. — On construction of curve of variation in measurements from given plants or animals.

Laboratory demonstration. — Stained egg cells (*ascaris*) to show chromosomes.

Laboratory demonstrations. — To illustrate the part played in plant or animal breeding by

(*a*) selection.

(*b*) hybridizing.

(*c*) budding and grafting.

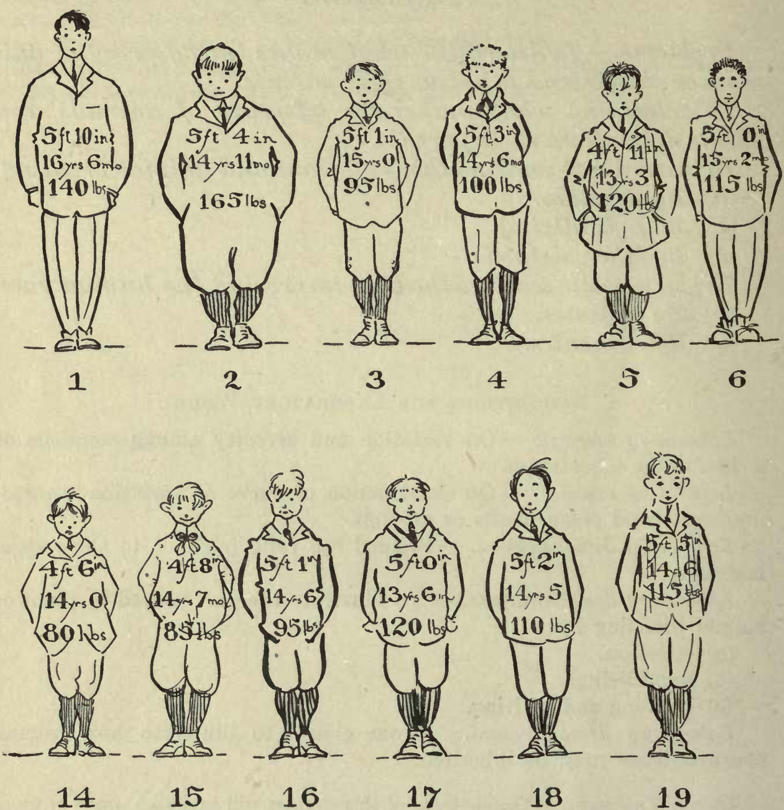
Laboratory demonstration. — From charts to illustrate how human characteristics may be inherited.

To the Teacher. — The contents of this chapter will probably prove of more interest and, if seriously taken up by teacher and pupils, of more lasting value than any other part of the course. The immense significance of variation and heredity and the application of these factors in eugenics certainly make a theme of vital interest. The direct teaching of sex hygiene in the public secondary school is not recommended, both because of lack of preparation on the part of teachers, because of the intimacy of contact required between teacher and pupil, making work with

large groups impracticable, and because the proper place for such direct teaching is in the home. It *is*, however, the function of biology to teach the primary facts known about reproduction and heredity as applied in plant and animal breeding. On these facts the child of to-day will build for the experiences of to-morrow.

***Problem 150**: To determine if there is individual variation in any one measurement of the members of a given class.*

Materials. — String, ruler.



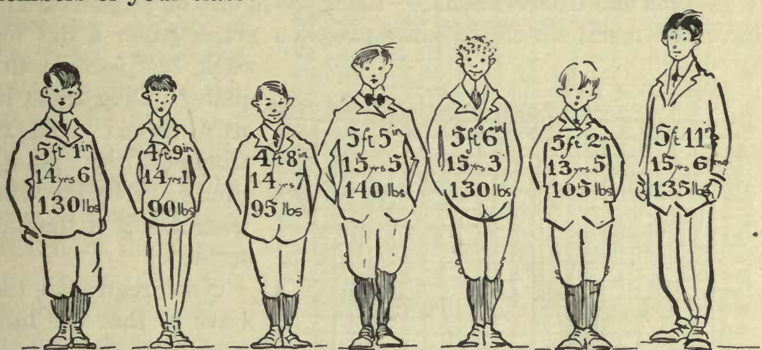
Method. — With the string carefully measure the circumference of your right wrist.

Observations. — Verify your figures by having your neighbor take the measurement for you. Do the same thing for him. The

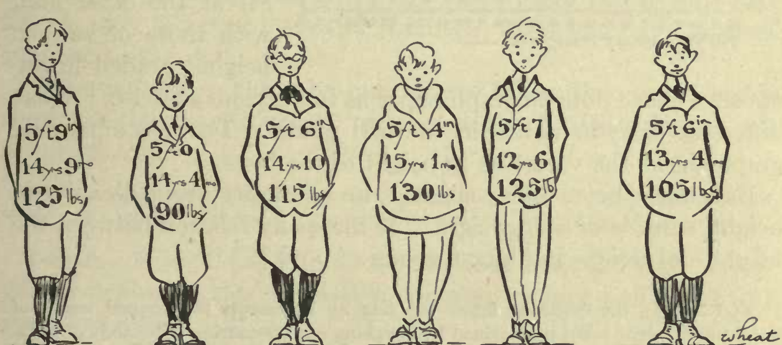
instructor will give you an individual number. Hand in your results with your number to one pupil of the class who will tabulate the figures on the board.

Make a graph showing the individual variation in circumference of the wrist in the members of your class.

Conclusion. — Is there variation in this measurement among the members of your class?



7 8 9 10 11 12 13



20 21 22 23 24 25

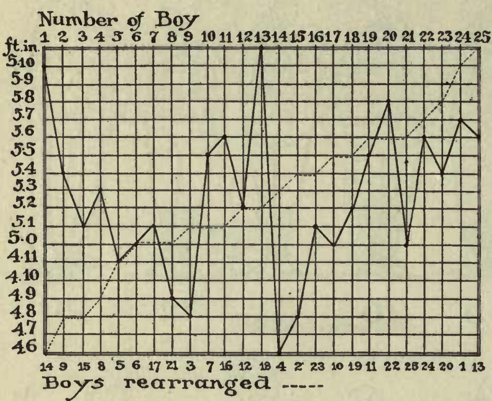
NOTE. — Exercises on variation are numerous and may be worked out from charts, from collected material showing variations, or from work done by pupils in the field. In every case where possible, a graph should be made to illustrate the normal and the variation from the normal. The exercise that follows will show the method to be used.

***Problem 151:** To show variation in a given class.*

Materials. — Figures on pages 174, 175. Later the measurements of the individual boys or girls of a class.

a. Variation in Height

Method and Observations. — Using the figures on pages 174, 175 have the members of the class place on graph paper a dot for each boy seen in the plate, taking them in numerical order. Connect the points made. Notice the irregularity of the line formed.



Now rearrange the boys so that the tallest is at one end of the line and the shortest at the other end, with those of various heights graded in between. Place dots on graph paper as in previous exercise. What difference do you notice in the line made? The accompanying graph shows the variation in height of the boys.

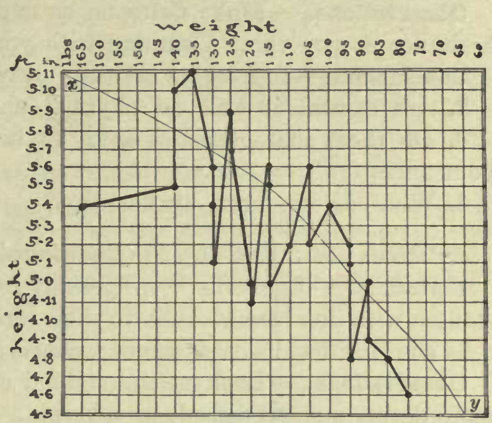
But these boys differ slightly in mentality, considerably in height, considerably in weight. Is there any relation between the height and weight in a given group of boys?

NOTE. — In the following figure the line *xy* represents the normal curve of weight and height relation obtained by weighing and measuring thousands of boys.

b. To Form a Curve Showing the Relation of Weight to Height in a Given Class

Method. — Notice that a boy of 4 feet 5 inches should weigh 65 pounds, while a boy 5 feet 11 inches should weigh 170 pounds. Knowing your own height, note what your weight should be.

But we find that most of us differ slightly from the normal and in the class represented the first boy is 5 feet 10 inches tall and weighs 140 pounds, while the boy number 10 is but 5 feet 5 inches in height and also weighs 140 pounds.



Arrange your graph paper as shown at the right, with the greater weights to the left of the page and the less at the right. The heights are to be given vertically at the left side of the paper. Now pick out the members of the class and arrange them according to their weights and heights, placing a dot on the graph paper at the intersection of a given weight and height (as in the case of the boy who weighs 165 pounds and who is only 5 feet 4 inches in height). After you have finished connect all the dots.

Observations. — Does the line formed follow the normal curve shown in the chart (line *xy*) or does it vary? How do you account for this?

NOTE. — This curve you have made is called the curve of correlation between weight and height. We might also correlate age and weight, or age and height.

Conclusion. — Using the above method, make a curve of correlation showing the correlation between weight and height in your own class.

Problem 152: Does heredity play any part in our lives?

Materials. — Statistics gathered by class demonstrations.

Method. — Let each member of the class try to bring photographs of his parents and if possible of their parents. Write down a list of all the physical traits or likenesses you can find in your own family. Bring in written or verbal reports given by your

parents or, if possible, your grandparents, telling of any mental or physical characteristics they may find repeated in you from an earlier generation.

Observations. — Make notes on as many striking cases of inheritance as you can. Compare with your own case.

Conclusion. — 1. Are we in any ways like our ancestors?
2. Are mental as well as physical characteristics inherited?
3. Do these characteristics seem to be the same as those in your ancestors?
4. What do we mean by heredity?

Problem 153: *To study the fine structure of an egg cell.*

Materials. — Egg cells, — preferably from *ascaris* (a worm), — stained with iron hæmatoxylin to show nucleus and chromosomes; cells showing fertilization stages; charts; books.

Observations. — Look at the stained cells each lying within a more deeply stained capsule or covering. What structure do you find within it? (Compare figure on page 252, *Civic Biology.*) Look for the chromosomes within the nucleus. How many can you find?

NOTE. — The chromosomes in the cells of the body are always definite in number for every species of animal and vary from two in *ascaris* to over 150 in Crustaceans. In man there are sixteen. The chromosomes are believed to carry the hereditary qualities from one generation to the next.

Examine stained specimens that show fertilization and study carefully the figure on page 252, *Civic Biology.*

NOTE. — Before fertilization takes place, the number of chromosomes in each sperm and egg cell is reduced one half. Each cell, so far as the chromosomes are concerned, is now a half cell.

Conclusion. — 1. What happens when fertilization takes place? Study the figure.

2. If new characters are brought to the new animal or plant by means of the chromosomes, then what part would fertilization play in heredity? In variation?

Problem 154: *How selection is made.*

Materials. — Corn on ear, photographs or description of different corn plants.

Observations. — Compare several ears of corn and select the ear which has most even rows, largest kernels, etc. Suppose this ear came from a plant which had but few ears. Would you select for planting, ears from this plant or ears which were not quite so perfect from a plant with more ears?

Conclusion. — In selecting seed for planting, what are some of the factors to be kept in mind?

Problem 155: A practical result of selection.

NOTE. — In a government test of corn to increase the yield, ears were chosen from plants that gave a high yield and the seed planted in rows. Next year seed from these rows was planted in rows alternating with seed from equally good-looking ears from the same kind of corn grown in the field. Note the results with eight pairs of ears.

POUNDS OF CORN YIELDED BY THE SEED OF ONE EAR

FIELD EARS	EARS FROM HIGH-YIELDING PARENTS
170 lbs.	177.5 lbs.
139.5 "	180 "
139 "	199 "
173 "	197 "
154 "	172 "
133 "	176 "
156.5 "	194 "
153 "	200.5 "

Observations. — What per cent of increase was there from the selected corn?

If the seed from the field-grown corn yielded 42 bushels per acre, what would have been the gain per acre by planting seed from the selected corn?

Conclusion. — State results both in bushels and in dollars, corn being worth 75 cents per bushel.

Problem 156: To determine some means of selection of fruit trees from the economic standpoint.

Method and Observations. — Given an area 1000 feet long and 500 wide, which might be planted as follows:

(1) Trees 20 feet apart, bear after five years, average five hundred apples per tree, continue bearing twenty-five years. Apples wholesale $1 per hundred.

(2) Trees 22 feet apart, bear after seven years, average six

hundred apples, sell $1.75 per hundred, continue bearing thirty years.

(3) Trees 25 feet apart, bear after six years, produce four hundred and fifty apples per tree, continue bearing forty years, price $2.25 per hundred.

(4) Trees 18 feet apart, bear after five years, average three hundred and fifty apples per tree, bear for twenty years, average price $3 per hundred.

(5) Trees 30 feet apart, bear after six years, average six hundred and fifty apples per tree, continue bearing twenty-five years, average price $2 per hundred.

(6) Trees 24 feet apart, bear after six years, average five hundred apples, bearing thirty years, average price $3.25 per hundred.

(7) Trees 20 feet apart, bear after four years, average two hundred and fifty apples per tree, continue bearing thirty years, price per hundred $3.75.

Conclusion. — Which of the above would you choose to grow in the area? Give your reasons.

Problem 157: *How hybridization is accomplished in flowering plants.*

Materials. — Plants in flower, manila bags, camel's-hair brush.

Method. — Tie a manila bag over a growing apple or pear bud (or any other large available flower) that is about to open. Remove from another flower of the same family, but another species, all parts except the pistil, before the flower opens. Cut at line marked *W* on figure. Tie a bag over it also.

When the flower in the first bag opens, transfer some of the pollen to the stigma of the flower without stamens. This may be done by means of a small camel's-hair brush. Cover the surface of the stigma with pollen. Label the stigma thus pollinated, stating the date, and all data concerning source of pollen, etc.

Observations. — Why do we cover the

flowers in this experiment? Why such care in the transfer of pollen? What ought to happen after the transfer of the pollen?

Conclusion. — 1. Remembering that the egg cell from one flower has united with the sperm cell of another flower, if the operation has been successful, what characters ought the new plant to have? Explain.

2. What is the use of hybridization?

Problem 158: Other methods used in plant breeding.

Materials. — Examples of budding, grafting, layers, and slips. Charts and texts.

Observations. — Notice carefully what has been done in making a tongue graft, a cleft graft. Study the steps in budding (page 256, *Civic Biology*). Consult any good book on agriculture to see how layering and slipping are done.

Conclusion. — 1. How might these processes enable man (*a*) to form new kinds of plants? (*b*) to reproduce useful plants (see page 255, *Civic Biology*)?

2. What kind of reproduction is this called, sexual or asexual? Explain your answer in a well-written paragraph.

Problem 159: To determine the working of Mendel's Law.

Materials. — Text illustrations, charts, material illustrating Mendel's Law.

Observations. — Study the illustrations very carefully. Notice that there are three possibilities of offspring: those having dominant, recessive, and mixed

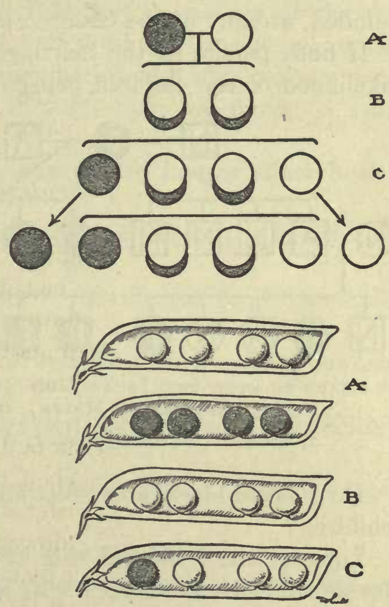


DIAGRAM TO ILLUSTRATE MENDEL'S LAW. WHITE DOMINANT, BLACK RECESSIVE, CHARACTER.

A, first generation; *B*, second generation; *C*, third generation.

characters. What will happen if animals or plants having pure dominant characters are bred together? Pure recessive characters? Mixed characters? (See chart.) What would be the proportion of dominants, recessives, and mixed offspring in the next generation if breeding continued as in *A*?

Conclusion. — Why is Mendel's Law of great value to plant and animal breeders? Explain.

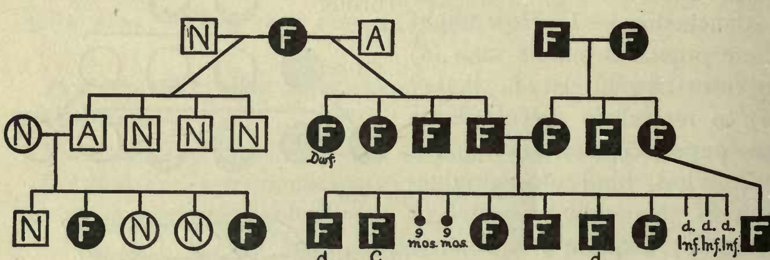
Problem 160: *To determine some means of bettering, physically and mentally, the human race.*

Materials. — Charts adapted from Davenport, Goddard, etc. showing heredity of feeble-mindedness, alcoholism, epilepsy, etc.

Method. — Careful study of the charts to answer the questions.

Observations. — If one of the parties in a marriage is feeble-minded, are any of the children likely to be feeble-minded?

If both parties in the marriage are feeble-minded, what is the likelihood of the children being feeble-minded?



A Chart to show the Inheritance of Feeble-mindedness. The Squares Represent Males; the Circles, Females.

A, alcoholic; *F*, feeble-minded; *N*, normal; *d.inf.*, died in infancy.

Does alcohol have any effect on the production of feeble-minded children?

Look at the left-hand side of the chart shown above. Does feeble-mindedness there seem to be a dominant or recessive character? Explain.

Note to Teacher. — Other problems of a similar nature may be taken up and discussed with seriousness and exceptional interest even in mixed classes. The child is at the receptive age and is emotionally open to the serious lessons here involved.

Conclusion. — Should feeble-minded persons be allowed to marry?

***Problem 161**: Are good mental parts or qualities capable of transmission from parent to child?*

Materials. — Charts, reference books, etc.

Observations. — Study the chart to see if artistic ability may be inherited? Think of any case in your family of inheritance of some mental trait, such as musical ability.

Conclusion. — Are mental traits handed down?

***Problem 162**: Does control of our environment have anything to do with the problem of race betterment?*

Method. — A study of your own environment.

Observations. — Remembering that certain factors of the environment react upon the health and vitality of the people living within that environment and remembering also that certain germ diseases may enter the body through body openings or even through scratches or cuts, then

(1) How might dirty streets, stores, and houses affect health in a neighborhood?

(2) How might the milk or water supply affect the health in a given neighborhood?

(3) What effect might improper or insufficient food have upon persons within a given locality?

(4) How might any of these factors affect the health of mothers with newly born children?

(5) Might such factors as mentioned above affect these babies? If so, how?

(6) Knowing what we do about disease germs, should we use public drinking cups? Explain.

(7) How might public roller towels be dangerous?

(8) What other factors of the environment might work against a healthy race? Explain.

Conclusion. — 1. What factors of the environment have to do with the betterment of the race?

2. How could you improve your own environment?

Problem Questions

1. What do we mean by variation? Heredity?
2. Show how these factors work in plant or animal breeding.
3. What is hybridization?
4. Who is Luther Burbank and what has he done?
5. Why should farmers select seeds with great care?
6. What part of egg and of sperm cells has to do with heredity?
7. Who was Mendel, and what is his law?
8. What did De Vries do in the problem of heredity?
9. What is meant by eugenics?
10. What is meant by euthenics?
11. How might alcohol play a part in the problem of heredity? (See *Civic Biology*, pages 289–294, 361–372.)
12. What have clean thoughts to do with a clean body?

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XVIII. THE HUMAN MACHINE AND ITS NEEDS

Problem. — *To obtain a general understanding of the parts and uses of the bodily machine.*

Laboratory Suggestions

Demonstration. — Review to show that the human body is a complex of cells.

Laboratory demonstration by means of (*a*) human skeleton and (*b*) manikin to show the position and gross structure of the chief organs of man.

To the Teacher. — As in certain of the previous chapters, the student here takes a preliminary view of the general problem that lasts for the rest of his course in biology, *i.e.*, that of adaptation to function in the human body. A general survey gives an initial interest in problems which are solved later; it defines the future problems and marks the beginning of some new concepts. Certain structures of the body, as, for example, bones and muscles, are now treated and dismissed, not because of their non-importance, but because of the time demanded by the more practical questions relating to dietaries and bodily nutrition.

Problem 163: *To show that the human body is made up of cells.*

Materials. — Scalpel, methyl blue, glass slides, cover glasses, microscope.

Method. — Scrape mucous lining from the mouth, mount on a glass slide, and stain with a drop of dilute methyl blue. Cover with cover glass and examine under microscope.

Observations. — The large irregular bodies with dark blue bodies within them are flat cells (*epithelium*) from the lining of the mouth. What are these dark blue structures within the cell? (The small dots or rods stained deep blue are *bacteria*.)

Cells from other parts of the body, gland, muscle, nerve, etc., should be demonstrated under the compound microscope.

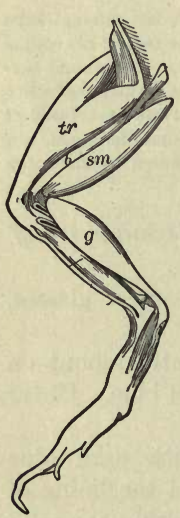
Conclusion. — What are the units of building material in the body?

Problem 164: *To find out some functions of the skin.*

Materials. — Hand lens, ether or alcohol, large glass jar, two thermometers, model or chart of skin.

Method and Observations. — Find out whether all parts of the skin are equally sensitive, by touching with the sharp point of a pencil. Cool a large glass jar, and hold the hand and wrist in the jar for a few moments, closing the opening of the jar with a cloth or a towel. What collects on the inner surface of the jar? What happens when you take violent exercise? Weigh yourself before and after a period of hard work in the gymnasium. Is there any loss in weight? How do you account for it? Place a few drops of ether or alcohol on the back of the hand and note the evaporation of the liquid. What sensation do you feel while the evaporation takes place?

Study the model or figure, page 342, *Civic Biology*. Locate the two layers by means of your textbook. Find and describe the sweat glands, oil glands, and sense organs. Draw a diagrammatic sketch of the model and label all parts. Write a statement giving the function of each part.



MUSCLES OF THE LEFT LEG OF THE FROG.

b, biceps; *g*, gastrocnemius; *sm*, semi-membranosus; *tr*, triceps.

Conclusion. — 1. Is the skin an organ of sensation?

2. What passes off through the skin?

3. What result to your bodily comfort does this last function have?

Problem 165: *To study the use of the muscles.*

Material. — Frogs preserved in formalin.

Method. — Remove the skin from the hind leg of a frog.

Observations. — Note the "flesh" forming the muscle of the leg. (The wide part or *belly* of a muscle is attached to the bone by a tough tendon.) Move the leg by pulling the foot up and down. What effect does this have on the muscle? To what are the muscles attached?

At how many points are they attached? Explain how movement of the leg results from *contraction* (shortening) of certain of the muscles. What must occur when some of the muscles contract? (Look at the position of the muscle on the opposite side of the leg.) Note the shape of your upper arm. To what is the rounded surface due?

Conclusion. — 1. Why do muscles cause movement? Explain fully.

2. What use, other than movement, have muscles?

***Problem 166**: To study the structure and uses of the skeleton.*

Materials. — Prepared human skeleton, manikin.

Observations. — Note that the skeleton is divided into two groups of bones: a main framework of the body, the *axial* skeleton; and a framework for the appendages, the *appendicular* skeleton. In life the bones are attached to each other by tough ligaments. Why are the bones jointed? Notice the bones of the head, skull, and face. Knowing that the skull covers part of the delicate nervous system, the brain, what would you say its use was?

Note that the backbone, made up of numerous pieces of bone, has a hole running through it. This hole contains in life the spinal cord.

Attached to the vertebræ of the backbone are the ribs. Compare the position on the manikin. What is one use of the ribs? Feel your own ribs; bend forward, and take a full breath. What is another function of your ribs? (Remember, to obtain movement, muscles must be attached to bones. Why?)

Notice that the arm is attached to the main skeleton by means of two bones, the collar bone and the shoulder blade. These bones form the *pectoral* girdle. The leg is in the same way attached to a group of strong bones called the *pelvic* girdle.

Notice various bones, such as the long arm bone (humerus), shoulder blade, pelvic bones, the spines on the ribs, for roughness

To THE TEACHER. — A demonstration should be shown at this point to illustrate the structure of striated and plain muscle tissue. Detailed laboratory work on this material is not desirable.

where muscles might be attached. In each case seek a place for attachment for the other end of the muscle.

Conclusion. — 1. Write a statement giving three general uses of the human skeleton. Take a special bone or bones to illustrate each use.

2. Compare the skeleton with the figure on page 268, *Civic Biology*. Make a drawing to identify the principal bones.

***Problem 167**: To find the relation of muscles to bones in the human body.*

Method. — Using the diagrams in your *Civic Biology*, page 269, work out the different classes of levers.

Observations. — In the human body which class of lever is represented when we raise a weight in the hand? What kind of lever do we use when we rise on the toes? What kind of lever do we use when we nod the head?

Conclusion. — 1. Prove that three classes of levers are present in the human body.

2. Find another example of each kind of lever in the human body.

***Problem 168**: To study the joints of the human body.*

Materials. — Human skeleton.

Method. — Study the following joints in the human skeleton: arm at shoulder, knee, head on neck bones, bones of spinal column. Move them in each case.

Observations. — Is the joint hinge-like, ball and socket, gliding, or rotary?

Conclusion. — 1. How many different kinds of joints can you find in a skeleton?

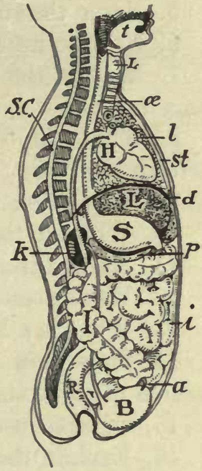
2. What are their specific uses?

***Problem 169**: To get a preliminary survey of the internal structure of the human body.*

Materials. — Manikin and charts showing organs of the human body.

Observations. — If we compare the human body to a machine, then the bones and muscles are the framework. Within the body,

partially protected by the ribs, is a cavity, the *body cavity*, divided into two unequal parts by a wall of muscles, the *diaphragm*. The body cavity contains the working parts of the machine: *a*. The organs of digestion, *gullet, stomach, small intestine, large intestine,* the *liver* and *pancreas* (two digestive glands), and the *spleen* (a gland connected to the digestive organs). *b*. The organs of respiration, the *lungs* and *tubes* which connect them with the outside of the body. *c*. The organs of circulation, the *heart* and *blood vessels*. *d*. The organs of excretion, the *kidneys*. *e*. Most important of all is the *nervous system*. This consists of the *brain* and *spinal cord* with the *nerves* growing out from them, and several different *sense organs*, which are at the outside of the body and send nerves inward to connect with the central nervous system.



THE ORGANS WITHIN THE HUMAN BODY. READ FROM ABOVE DOWN:

t, tongue; *L*, larynx; *œ*, gullet; *l*, lung; *H*, heart; *st*, sternum; *s.c*, spinal cord; *d*, diaphragm; *L*, liver; *S*, stomach; *k*, kidney; *p*, pancreas; *i*, small intestine; *I*, large intestine; *a*, vermiform appendix; *B*, bladder; *R*, rectum.

Your instructor will demonstrate these to you. We will spend most of the remainder of our course in learning more about the use of these various organs in the human machine.

Conclusion. — 1. What are the chief organs of the human body cavity?

2. Which of these are in the body cavity and which extend into other parts of the body?

3. Which are chiefly outside the body cavity but send branches in? (Get help from your instructor or your textbook, page 271, *Civic Biology*.)

4. Why are sense organs in the skin? How do they send messages to other parts of the body?

PROBLEM QUESTIONS

1. What is the unit of structure in the human body?

2. Why do the cells in different parts of the body differ in shape and size?

3. Of what use is the skin to man?

4. Would the skin serve the same purposes in the frog as in man?

5. Name the functions of muscles.

6. How do muscles work? Explain fully.

7. Explain the difference between a voluntary and an involuntary muscle.

8. What effect would working of the muscles have upon heat within the body? Explain.

9. What effect might muscular work have upon the skin?

10. Why are the muscles arranged in pairs?

11. Name three uses of the skeleton.

12. What attaches muscles to bones?

13. What is a lever? Give examples.

14. Show how some one part of the body might illustrate the action of three classes of levers.

15. Of what use are the joints?

16. Explain the difference between a break and a sprain.

17. What is the body cavity?

18. Which sets of organs are found entirely in the body cavity?

19. Which organs are found partially in the body cavity?

20. Why might the nervous system be called the "director of the body"?

Reference Books

Hunter, *Civic Biology*, Chap. XVIII. American Book Company.
Hunter, *Elements of Biology*, Chaps. XXXI, XXXII. American Book Company.
Hunter, *Essentials of Biology*, Chap. XXIII. American Book Company.
Davison, *Human Body and Health* (Advanced), Chap. XVII. American Book Company.
Goldmark, *Fatigue and Efficiency*. Charities Publication Committee.
Gulick, *The Gulick Hygiene Series*. Ginn and Company.
Gulick, *Physical Education by Muscular Exercise*. P. Blakiston's Son and Company.
Hall, *Elementary Anatomy*. American Book Company.
Halliburton, *Kirkes Handbook of Physiology*. P. Blakiston's Son and Company.
Hammarsten, *Textbook of Physiological Chemistry*. J. Wylie and Son.
Hawk, *Practical Physiological Chemistry*. P. Blakiston's Son and Company.
Hough and Sedgewick, *The Human Mechanism*, Chap. II. Ginn and Company.
Howell, *Physiology*. W. B. Saunders.
Hutchinson, *Exercise and Health*. Outing Publishing Company.

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Overton, *General Hygiene.* American Book Company.
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Ritchie, *Human Physiology,* Chaps. III–V. World Book Company.
Schafer, *Textbook of Physiology.* The Macmillan Company.
Sharpe, *Laboratory Manual in Biology,* pp. 218–225. American Book Company.
Stewart, *Manual of Physiology.* W. B. Saunders.
Stiles, *Nutritional Physiology.* W. B. Saunders.
Verworn, *General Physiology.* The Macmillan Company.

XIX. FOODS AND DIETARIES

Problems. *— A study of foods to determine:*

(*a*) *Their nutritive value.*

(*b*) *The relation of work, environment, age, sex, and digestibility of foods to diet.*

(*c*) *Their relative cheapness.*

(*d*) *The daily Calorie requirement.*

(*e*) *Food adulteration.*

(*f*) *The relation of alcohol to the human system.*

Laboratory Suggestions

Laboratory exercise. — Composition of common foods. The series of food charts supplied by the United States Department of Agriculture makes an excellent basis for a laboratory exercise to determine common foods rich in (*a*) water, (*b*) starch, (*c*) sugar, (*d*) fats or oils, (*e*) protein, (*f*) salts, (*g*) refuse.

Demonstration. — Method of using bomb calorimeter.

Laboratory and home exercise. — To determine the best individual balanced dietary (using standard of Atwater, Chittenden, or Voit) as determined by the use of the 100-Calorie portion.

Demonstration. — Tests for some common adulterants.

Demonstration. — Effect of alcohol on protein, *e.g.*, white of egg.

Demonstration. — Alcohol in some patent medicines.

Demonstration. — Patent medicines containing acetanilid. Determination of acetanilid.

To the Teacher. — The practical work in this chapter, although outlined to take not more than two to three weeks, has such possibilities of interest and importance that more time may well be spent in its consideration. The working out of an individual or family dietary with an estimate of the cost is an exercise that appeals strongly to the average pupil. Food economy and the balance of a ration are needed topics in every household to-day.

The practical correlation of work in biology with that of home economics is found here. It might well be worth while to expand this side of the course with girls so that several weeks be devoted to the practical side of dietetics. Much of

the laboratory work can be transferred to the laboratory of home economics or to the home.

Problem 170: How to determine the nutritive value of food.

Materials. — Set of government charts on food values. Tables on pages 276, 278, 279, *Civic Biology.*

NOTE. — Food has two possible values: it may be oxidized to release energy or it may help build tissue. The burning value of foods may be measured by heat units called *Calories* (a Calorie is the amount of heat needed to raise the temperature of a kilogram of water through one degree centigrade). Remember food is composed of nutrients, water, and refuse. Therefore not all food taken into the body is made use of.

Observations. — In the chart on page 276, *Civic Biology*, determine the actual percentage of nutrients in beef, potatoes, oysters, and corn meal. Do all foods have equal nutritive value?

From the government charts make a table in which you will place:

(*a*) Ten foods rich in protein (15 per cent or more).

(*b*) Ten foods rich in carbohydrates (50 per cent).

(*c*) Ten foods rich in fat (50 per cent or more).

(*d*) Ten foods having a high fuel value (1500 Calories or more per pound).

(*e*) Ten food substances that are over 50 per cent water. How would water affect the cost of food, providing you had to pay for the water?

(*f*) Five foods rich in mineral salts.

Conclusion. — In your opinion which of the foods shown are the best tissue-building foods? The best energy-producing foods? Explain. Remember that living matter is made up of carbon, oxygen, hydrogen, nitrogen, sulphur, and a minute amount of mineral salts.

Problem 171: The use of the bomb calorimeter. (Optional.)

The bomb calorimeter may be demonstrated by the instructor and its mechanism explained. Boys should be urged to try to experiment at home with homemade apparatus. An interesting series of home experiments on the burning value of different food substances worked out first hand will do much toward getting individual interest in the topic. Girls should approach this entire subject from the side of household economics. Much work can be done in household economics that will be scientifically explained in the biological laboratory, the two subjects giving and taking much from common ground.

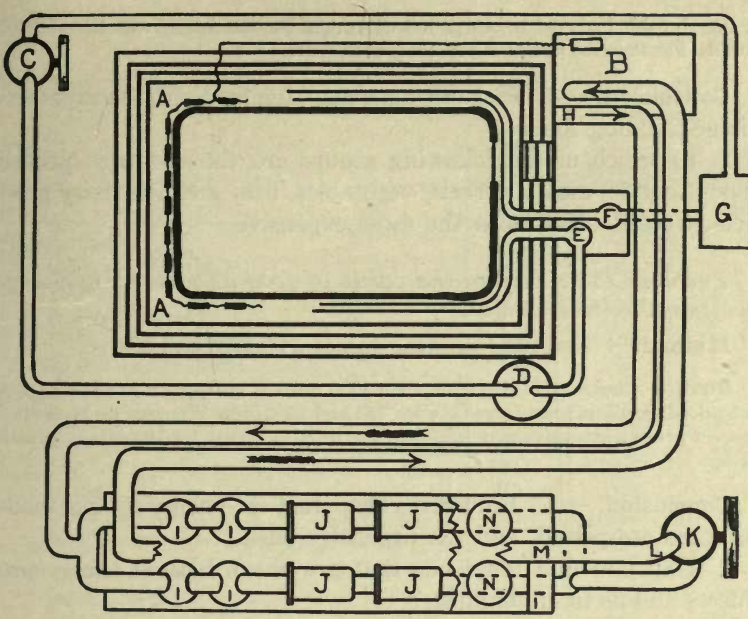
The experiments of Atwater with the respiration calorimeter should be explained and pictures of the apparatus shown so that the pupils may be impressed with the delicacy and magnitude of the experiments. This respiration calorimeter is described by Professor Atwater as follows:

"Its main feature is a copper-walled chamber 7 feet long, 4 feet wide, and 6 feet 4 inches high. This is fitted with devices for maintaining and measuring a ventilating current of air, for sampling and analyzing this air, for removing and measuring the heat given off within the chamber, and for passing food and other articles in and out. It is furnished with a folding bed, chair, and table, with scales and appliances for muscular work, and has telephone connection with the outside. Here the subject stays for a period of from three to twelve days, during which time careful analyses and measurements are made of all material which enters the body in the food, and of that which leaves it in the breath and excreta. Record is also kept of the energy given off from the body as heat and muscular work. The difference between the material taken into and that given off from the body is called the balance of matter, and shows whether the body is gaining or losing material. The difference between the energy of the food taken and that of the excreta and the energy given off by the body as heat and muscular work is the balance of energy, and if correctly measured, should equal the energy of the body material gained or lost. With such apparatus it is possible to learn what effect different conditions of nourishment will have on the human body. In one experiment, for instance, the subject might be kept quite at rest, and in the next do a certain amount of muscular or mental work with the same diet as before, then by comparing the results of the two, the use which the body makes of its food under the different conditions could be determined; or the diet may be slightly changed in the one experiment, and the effect of this on the balance of matter or energy observed. Such methods and apparatus are very costly in time and money, but the results are proportionately more valuable than those from simpler experiments."

The experiments of Chittenden should also be explained. (See Chittenden's *Nutrition of Man.*)

Atwater's Calorimeter. (See diagram on page 197.)

Atwater's respiration calorimeter, an apparatus for determining the income and outgo of energy, and respiratory products of the human body, under varying conditions, consists of an air-tight copper chamber, insulated from the surrounding air by a zinc casing and three wooden ones, with dead-air spaces between. It is provided with a door and a window for the introduction and removal of food. Closely attached to the outside of the copper wall are 304 thermoelectric couples (*A*) which, electrically, report the temperature of the calorimeter chamber to the observer's table (*B*). The temperature of the chamber is maintained as nearly constant as possible by a current of cold water, pumped by the electric pump (*C*) through the cooling tank (*D*) to (*E*), where its temperature is taken just before it enters the large-surface, winged pipes around the chamber. When the water emerges at (*F*), its temperature is taken again and its volume and flow measured at the water meter (*G*) before it returns to the pump. From these data, knowing the rise in temperature and the amount of water so raised, the amount of heat developed within the calorimeter may be computed. The flow of water may be regulated so as to carry off any amount of heat developed.



In order to assure accurate work on the respiratory products, the system of ventilation is also a closed one. The vitiated air is drawn out by the pipe (*H*), and then through a double row of vessels of sulphuric acid (*I*, *I*, *I*, *I*) to remove water vapor, and vessels of soda lime (*J*, *J*, *J*, *J*) to remove CO_2, to the electric pump (*K*). From here it is returned through pipe (*L*) to (*M*), where any deficiency in oxygen is noted and remedied from a tank of that gas before it is pumped through the regulating pans (*N*, *N*) into the chamber.

Method. — Using the diagram and explanation, try to explain to your own and your teacher's satisfaction the working of the Atwater calorimeter.

Conclusion. — What is the practical value of the apparatus?

Problem 172: *To find the value of food as a tissue builder compared with its cost.*

Method. — Use the tables on pages 198–201; make sure you understand the various column headings.

NOTE. — Foods may be considered cheap if they furnish more than .12 of a pound of protein (the tissue builder) for 10 cents at present prices; medium priced

if they furnish from .06 to .12 pound of protein for ten cents; expensive if they furnish less than .06 pound of protein for ten cents.

Conclusion. — 1. Pick out ten cheap, ten medium, ten expensive tissue-building foods.

2. In which of the following groups are the cheapest protein foods found: meats, cereals, vegetables, fish, shellfish, dairy products, fruits? Note also the most expensive.

***Problem 173**: To find the value of food as a source of energy compared with its price.*

Method. — Use the following tables as suggested above.

NOTE. — Cheap foods give more than 1500 units of energy for 10 cents at present prices; medium priced give between 750 and 1500 units of energy for 10 cents at present prices; expensive give less than 750 units of energy for 10 cents at present prices.

Conclusion. — 1. Find ten cheap fuel- or energy-giving foods, ten medium priced, and ten expensive ones.

2. Can you find ten foods that are cheap both as energy producers and as tissue builders?

NOTE. — An interesting exercise on economic buying of foods for a family or for individual consumption may be worked out from this table, which has been revised by inserting present-day prices. This is of especial value in connection with work in home economics.

COMPARATIVE NUTRITIVE VALUES AND PRICES OF FOOD MATERIALS[1]

	Price per Pound in Cents	Ten Cents will Purchase	
		Protein in lbs.	Fat and Carbo. Energy Calories
Beef			
Porterhouse steak	32	.050	325
Sirloin steak	28	.058	370
Round steak (top round)	28	.079	370
Chuck steak	22	.070	420
Flank steak	22	.077	510

[1] Revised by John W. Teitz of the Department of Biology, De Witt Clinton High School.

Comparative Nutritive Values and Prices of Food Materials — *Continued*

	Price per Pound in Cents	Ten Cents will Purchase	
		Protein in lbs.	Fat and Carbo. Energy Calories
Beef — Continued			
Porterhouse roast	30	.054	350
Rib roast	25	.056	470
Bottom round	20	.082	300
Plate (corned beef)	10	.138	1290
Shank (soup beef)	12	.107	455
Veal			
Cutlets	30	.069	170
Loin and rib	26	.065	270
Leg	25	.063	215
Breast	22	.098	290
Neck (stew veal)	20	.080	255
Knuckle or shank (veal broth)	15	.138	395
Mutton and Lamb			
Loin	30	.046	490
Leg	23	.065	390
Shoulder	20	.060	370
Neck (stew lamb)	16	.183	1480
Pork			
Ham, fresh	23	.067	670
Ham, smoked	23	.062	730
Shoulder, fresh	18	.067	820
Shoulder, smoked	18	.078	760
Ribs and loins	24	.056	635
Fat salt pork	16	.012	2295
Bacon	22	.042	1265
Poultry			
Turkey	32	.052	340
Chicken	24	.058	325
Sea Foods			
Bluefish	14	.072	150
Cod, fresh	15	.112	224
Cod, salted	16	.119	200
Halibut, fresh	20	.072	240
Halibut, smoked	25	.078	380
Mackerel, fresh	12	.096	305
Mackerel, salt	15	.109	688
Salmon, canned	25	.088	370

COMPARATIVE NUTRITIVE VALUES AND PRICES OF FOOD MATERIALS — *Continued*

	PRICE PER POUND IN CENTS	TEN CENTS WILL PURCHASE	
		Protein in lbs.	Fat and Carbo. ENERGY Calories
Sea Foods — Continued			
Clams in shells	40 per peck	.025	79
Lobsters, canned	45	.041	135
Oysters, solids	18	.030	130
Dairy Products			
Butter	32	.003	1135
Cheese	21	.096	940
Eggs	23	.058	280
Milk, whole	4.5	.072	720
Milk, skimmed	3	.102	565
Milk, condensed	12	.073	1260
Cream	15	.034	1220
Vegetables			
Beans, green	4	.102	925
Beans, baked (canned)	15	.045	400
Beans, dried	7	.320	2580
Beets	2	.052	840
Cabbage	3	.047	415
Cauliflower	3	.036	465
Celery	7	.032	250
Corn, green	3	.040	600
Corn, canned	15	.028	455
Onions	4	.033	515
Parsnips	2	.052	1200
Peas, split	7	.351	2515
Potatoes	2	.090	1555
Potatoes, sweet	3.5	.035	1085
Pumpkins	4	.013	150
Squash	4	.018	265
Tomatoes, canned	6	.020	175
Turnips	1.5	.060	835
Cereal Products			
Barley	7	.121	2355
Buckwheat	6	.069	2770
Corn meal	4	.230	4138
Hominy	5	.166	3300
Oatmeal (in pkgs.)	9	.185	2050

Comparative Nutritive Values and Prices of Food Materials — *Continued*

	Price per Pound in Cents	Ten Cents will Purchase	
		Protein in lbs.	Fat and Carbo. Energy Calories
Cereal Products — Continued			
Oatmeal (in bulk)	6	.278	3085
Rice	9	.089	1815
Flour, graham	4	.333	4170
Flour, rye	4	.170	4075
Flour, entire wheat	5	.275	3350
Flour, wheat	4	.285	4170
Bread, white	6	.154	2025
Crackers, soda	8	.134	2380
Miscellaneous			
Cornstarch	8	—	1850
Molasses	6	—	2580
Olive oil	70	—	605
Sugar	5	—	3756
Tapioca	9	—	1855
Lard	16	—	2435
Sausage	22	.060	965
Fruits			
Apples	2	.021	700
Apples, dried	18	.010	750
Apricots, dried	10	.047	1290
Bananas	8	.096	375
Berries	6	.007	290
Cherries	6	.015	575
Cranberries	5	.008	430
Dates	12	.016	915
Figs	20	.022	745
Grapes	4	.025	840
Muskmelons	7	.005	640
Oranges	6	.014	390
Peaches	5	.020	510
Peaches, canned	10	.008	255
Pears	4	.015	735
Pineapple	10	.004	200
Prunes	12.5	.014	950
Raisins	15	.015	1045
Watermelons	4	.004	150

Problem 174*: *To find my daily Calorie requirement.

Method. — Use the following tables carefully.

TABLE 1

DAILY CALORIE NEEDS

For a child under 2 years	900 Calories
For a child from 2 to 5 years	1200 Calories
For a child from 6 to 9 years	1500 Calories
For a child from 10 to 12 years	1800 Calories
For girl from 13 to 14 years (woman, light work, also)	2100 Calories
For boy from 12 to 14, girl from 15 to 16 (man, sedentary)	2400 Calories
For boy from 15 to 16 years (man, light muscular work)	2700 Calories
For man (moderately active muscular work)	3000 Calories
For farmer (busy season)	3200 to 4000 Calories
For ditchers, excavators, etc.	4000 to 5000 Calories
For lumbermen, etc.	5000 and more Calories

NOTE. — According to Professor Chittenden, a person doing moderate work should not eat more than $\frac{1}{70}$ of an ounce of protein for each pound of his body weight and enough fuel foods added to bring the total up to between 2500 and 3000 Calories. This is a good general rule to follow. Still another check on your daily needs when doing light work may be obtained by multiplying your body weight by 16.1 Calories. The result will be approximately your daily Calorie requirement.

But the body needs more energy when it works hard. The hourly Calorie requirement is shown in the following table.

TABLE 2

HOURLY OUTGO IN HEAT AND ENERGY FROM THE HUMAN BODY AS DETERMINED IN THE RESPIRATION CALORIMETER BY THE UNITED STATES DEPARTMENT OF AGRICULTURE

AVERAGE (154 LB.)	CALORIES
Resting (asleep)	65
Sitting up (awake)	100
Light exercise	170
Moderate exercise	290
Severe exercise	450
Very severe exercise	600

Observations. — Make very careful observations in tabular form giving the exact Calorie requirement of your own body, using first the age requirement (see Table 1), second the sex requirement (Table 1), third the occupation requirement by the hourly standard (see Table 2). Use judgment in estimating light exer-

cise, moderate exercise, and severe exercise. No boy or girl in high school ever does *very severe exercise.* Light exercise might be taken to mean walking to school, moving about the house, etc. Moderate exercise would be setting-up drill, walking (not running) upstairs, or any exercise that will cause a slight perspiration. Severe exercise would be carrying heavy bundles, football, tennis, or basket ball during moments of active play. Use considerable care in making your estimate because of the value of this problem to you.

Conclusion. — 1. How do age, weight, occupation, and sex affect *your* daily Calorie requirement?

2. What is *your* daily Calorie requirement?

Problem 175: To find the proportion of protein, fat, and carbohydrate needed in my daily Calorie requirement.

Materials. — Tables, etc., in this volume and in Hunter's *Civic Biology.*

NOTE. — At least three different investigators have slightly different beliefs as to just what this proportion of protein, fat, and carbohydrate should be; but all agree in one detail, that the proportion of protein food used should be kept low.

The following table gives the proportion per 100 Calories as given by Atwater, Chittenden, and Voit, a German investigator.

	Cal. from Protein	Cal. from Fat	Cal. from Carbohydrate
Atwater	14	32	54
Chittenden	10	30	60
Voit	25	20	55

Of the three given above, the estimate of Chittenden is usually adopted for this country although some people believe that his proportion of protein is a little low. Foods taken into the body having these proportions of the nutrients constitute a *balanced ration* or *dietary* because they provide the body with the right proportion for tissue building as well as for fuel food.

Observations. — Compare the life you lead with that of a day laborer. Would your needs be the same?

Compare your life with that lived by an Eskimo in the Arctic regions. Would the proportion of the nutrients needed by him be the same as you need? Explain.

Conclusion. — 1. Would the same proportion of nutrients be needed in all localities?

2. Are there any other factors that might cause different proportions of the nutrients needed by individuals?

***Problem 176**: To obtain my daily dietary with the 100 Calorie table of Fisher and to make the necessary corrections in my dietary.*

Materials.— Dr. Irving Fisher of Yale University has worked out the following tables by means of which a person may easily estimate the number of Calories he receives from any given food. The use of these tables is explained in the laboratory exercise which follows.

TABLE OF 100 CALORIE PORTIONS[1]

NAME OF FOOD	PORTION CONTAINING 100 FOOD UNITS (APPROX.)	WT. OF 100 CALORIES (OZ.)	CALORIES FURNISHED BY		
			Protein	Fat	Carbohydrate
Cooked Meats					
Beef, round, boiled (fat)	Small serving	1.3	40	60	0
Beef, round, boiled (lean)	Large serving	2.2	90	10	0
Beef, round, boiled (med.)	Small serving	1.6	60	40	0
Beef, 5th rib, roasted	Half serving	.65	12	88	0
Beef, ribs, boiled	Small serving	1.1	27	73	0
Chicken, canned	One thin slice	.96	23	77	0
Lamb chops, broiled, av.	One small chop	.96	24	76	0
Lamb, leg, roasted	Ord. serving	1.8	40	60	0
Mutton, leg, boiled	Large serving	1.2	35	65	0
Pork, ham, boiled (fat)	Small serving	.73	14	86	0
Pork, ham, roasted (lean)	Small serving	1.2	33	67	0
Turkey, as purchased, canned	Small serving	.99	23	77	0
Veal, leg, boiled	Large serving	2.4	73	27	0

[1] These tables are here given by courtesy of *The Journal of the American Medical Association*, Vol. XLVIII, No. 16.

TABLE OF 100 CALORIE PORTIONS — *Continued*

NAME OF FOOD	PORTION CONTAINING 100 FOOD UNITS (APPROX.)	WT. OF 100 CALORIES (OZ.)	CALORIES FURNISHED BY		
			Protein	Fat	Carbohydrate
Uncooked Meats, Edible Portion					
Beef, loin, av. (lean) . .	Ord. serving .	1.8	40	60	0
Beef, loin, porterhouse steak, av.	Small steak .	1.3	32	68	0
Beef, loin, sirloin steak, av.	Small steak .	1.4	31	69	0
Beef, ribs, lean, av. . .	Ord. serving .	1.8	42	58	0
Beef, round, lean, av. .	Ord. serving .	2.2	54	46	0
Beef, tongue, av. . . .	Ord. serving .	2.2	47	53	0
Beef, juice	Two sm. cups .	14	78	22	0
Chickens (broilers), av. .	Large serving .	3.2	79	21	0
Clams, round in shell, av.	12 to 16 . . .	7.4	56	8	36
Cod (whole)	Two servings .	4.9	95	5	0
Goose (young) av.. . .	Half serving .	.88	16	84	0
Halibut steaks, av. . .	Ord. serving .	2.8	61	39	0
Liver (veal), av. . . .	Two sm. servings	2.8	61	39	0
Lobster (whole), av. . .	Two servings .	4.1	78	20	2
Mackerel (Span.), whole, av.	Ord. serving .	2	50	50	0
Mutton, leg, hind, lean, av.	Ord. serving .	1.8	41	59	0
Oyster in shell, av. . .	One dozen . .	6.8	49	22	29
Pork, loin, chops, av. .	Very sm. serving	.97	18	82	0
Pork, ham, lean, av. . .	Small serving .	1.3	29	71	0
Pork, bacon, med. fat, av.	Small serving .	.53	6	94	0
Salmon (Cal.), av. . .	Small serving .	1.5	30	70	0
Shad, whole, av. . . .	Ord. serving .	2.1	46	54	0
Turkey, av.	Two sm. servings	1.2	29	71	0
Vegetables					
Asparagus, av., cooked .	Two portions .	7.19	18	63	19
Beans, baked, canned .	Small side dish	2.66	21	18	61
Beans, string, cooked . .	Five servings .	16.66	15	48	37
Beets, edible portion, cooked	Three servings	8.7	2	23	75
Cabbage, edible portion .	Three servings	11	20	8	72
Carrots, cooked . . .	Two servings .	5.81	10	34	56
Cauliflower, as purchased	. . . .	11	23	15	62
Celery, edible portion .	Two med. b'chs	19	24	5	71
Corn, sweet, cooked . .	One side dish .	3.5	13	10	77
Cucumbers, edible portion	Six or seven serv.	20	18	10	72
Egg plant, edible portion	. . . .	12	17	10	73

Table of 100 Calorie Portions — *Continued*

Name of Food	Portion containing 100 Food Units (Approx.)	Wt. of 100 Calories (oz.)	Calories Furnished by		
			Protein	Fat	Carbohydrate
Vegetables — Continued					
Lentils, cooked	One portion .	3.15	27	1	72
Lettuce, edible portion .	Two sm. heads	18	25	14	61
Mushrooms, as purchased	. . . .	7.6	31	8	61
Onions, cooked	Two l'ge servings	8.4	12	40	48
Parsnips, edible portion .	One half serv. .	5.3	10	7	83
Peas, green, cooked . .	One serving .	3	23	27	50
Potatoes, baked . . .	One good-sized	3.05	11	1	88
Potatoes, boiled . . .	One large-sized	3.62	11	1	88
Potatoes, mashed (creamed)	One serving .	3.14	10	25	65
Potatoes, chips . . .	One half serving	.6	4	63	33
Potatoes, sweet, cooked .	Half av. potato	1.7	6	9	85
Pumpkins, edible portion	. . . .	13	15	4	81
Radishes, as purchased .	. . . .	17	18	3	79
Rhubarb, edible portion .	. . . .	15	10	27	63
Spinach, cooked . . .	Two ord. servings	6.1	15	66	19
Squash, edible portion .	. . . .	7.4	12	10	78
Succotash, canned . . .	Ord. serving .	3.5	15	9	76
Tomatoes, fresh, as purchased	Four av. servings	15	15	16	69
Turnips, edible portion .	Two l'ge servings	8.7	13	4	83
Fruits (Dried)					
Apples, as purchased . .	. . . .	1.2	3	7	90
Apricots, as purchased .	. . . .	1.24	7	3	90
Dates, edible portion . .	Three large . .	.99	2	7	91
Figs, edible portion . .	One large . .	1.1	5	0	95
Prunes, edible portion .	Three large . .	1.14	3	0	97
Raisins, edible portion .	. . . .	1	3	9	88
Fruits (Fresh or Cooked)					
Apples, as purchased . .	Two apples . .	7.3	3	7	90
Apples, baked	One serving .	3.3	2	5	93
Apples, sauce	Ord. serving .	3.9	2	5	93
Apricots, cooked . . .	Large serving .	4.61	6	0	94
Bananas, edible portion .	One large . .	3.5	5	5	90
Blackberries	One serving .	5.9	9	16	75
Blueberries	One serving .	4.6	3	8	89
Cantaloupe	Half ord. serving	8.6	6	0	94

TABLE OF 100 CALORIE PORTIONS — *Continued*

NAME OF FOOD	PORTION CONTAINING 100 FOOD UNITS (APPROX.)	WT. OF 100 CALORIES (OZ.)	CALORIES FURNISHED BY		
			Protein	Fat	Carbohydrate
Fruits (Fresh or Cooked) — Continued					
Cherries, edible portion .	Small dish . .	4.4	5	10	85
Cranberries, as purchased	. . . .	7.5	3	12	85
Grapes, as purchased, av.	Small bunch .	4.8	5	15	80
Grapefruit	Half	7.57	7	4	89
Grape juice	Small glass . .	4.2	0	0	100
Gooseberries	. . . .	9.2	5	0	95
Lemons	About two . .	7.57	9	14	77
Olives, ripe	About seven .	1.31	2	91	7
Oranges, as purchased, av.	One very large	9.4	6	3	91
Oranges, juice	Large glass . .	6.62	0	0	100
Peaches, as purchased, av.	Three ordinary	10	7	2	91
Peaches, sauce	Ord. serving .	4.78	4	2	94
Pears	One large . .	5.40	4	7	89
Pineapples, edible portion, av.	One serving .	8	4	6	90
Raspberries, red . . .	One serving .	6.29	8	0	92
Strawberries, av. . . .	Two servings .	9.1	10	15	75
Watermelon, av. . . .	. . . .	27	6	6	88
Dairy Products					
Butter	1 pat	.44	.5	99.5	0
Buttermilk	1½ glasses . .	9.7	34	12	54
Cheese, Am. pale . . .	1½ cubic in. .	.77	25	73	2
Cheese, cottage . . .	4 cubic in. . .	3.12	76	8	16
Cheese, cream	1½ cubic in. .	.82	25	73	2
Cheese, Swiss	1½ cubic in. .	.8	25	74	1
Cream	½ ord. glass. .	1.7	5	86	9
Milk condensed, sweetened	⅛ cup	1.06	10	23	67
Milk, condensed, unsweetened	¼ cup	2.05	24	50	26
Milk, whole	Small glass . .	4.9	19	52	29
Cakes, Pastry, Puddings, and Desserts					
Cake, chocolate layer .	½ ord. sq. piece	.98	7	22	71
Cake, gingerbread . . .	½ ord. sq. piece	.96	6	23	71
Cake, sponge	Small piece . .	.89	7	25	68
Custard, milk	Ord. cup . .	4.29	26	56	18

TABLE OF 100 CALORIE PORTIONS — *Continued*

NAME OF FOOD	PORTION CONTAINING 100 FOOD UNITS (APPROX.)	WT. OF 100 CALORIES (OZ.)	CALORIES FURNISHED BY		
			Protein	Fat	Carbohydrate
Cakes, Pastry, Puddings, and Desserts — Continued					
Custard, tapioca . . .	Two thirds ord.	2.45	9	12	79
Doughnuts	Half a doughnut	.8	6	45	49
Lady fingers	Two to three .	.95	10	12	78
Macaroons	Two to three .	.82	6	33	61
Pie, apple	One third piece	1.3	5	32	63
Pie, cream	One fourth piece	1.1	5	32	63
Pie, custard	One third piece	1.9	9	32	59
Pie, lemon	One third piece	1.35	6	36	58
Pie, mince	One fourth piece	1.2	8	38	54
Pie, squash	One third piece	1.9	10	42	48
Pudding, apple sago . .	One serving .	3.02	6	3	91
Pudding, cream rice . .	Very small serving	2.65	8	13	79
Pudding, Indian meal .	Half ord. serving	2	12	25	63
Pudding, apple tapioca .	Small serving .	2.8	1	1	98
Tapioca, cooked . . .	Ord. serving .	3.85	1	1	98
Sweets and Pickles					
Catsup, tomato, av. . .	⅓ qt. bottle . .	6	10	3	87
Honey	Four teaspoons	1.05	1	0	99
Marmalade, orange . .	Four teaspoons	1	.5	2.5	97
Molasses, cane	Four teaspoons	1.2	.5	0	99.5
Olives, green, edible portion	Seven olives .	1.1	1	84	15
Pickles, mixed . . .	. . . .	14.6	18	15	67
Sugar, granulated . . .	Three teaspoons or 1½ lumps .	.86	0	0	100
Sirup, maple	Four teaspoons	1.2	0	0	100
Nuts, Edible Portion					
Almonds, av.	Eight to fifteen	.53	13	77	10
Brazil nuts	Three ord. size	.49	10	86	4
Butternuts	About six . .	.50	16	82	2
Coconuts	. . . .	.57	4	77	19
Chestnuts, fresh, av. . .	⅙ of a cup . .	1.4	10	20	70
Filberts, av.	Ten nuts . .	.48	9	84	7
Hickory nuts	About ten . .	.47	9	85	6
Peanuts	Thirteen, double	.62	20	63	17

TABLE OF 100 CALORIE PORTIONS — *Continued*

Name of Food	Portion containing 100 Food Units (Approx.)	Wt. of 100 Calories (oz.)	Calories Furnished by		
			Protein	Fat	Carbohydrate
Nuts, Edible Portion — Continued					
Pecans, polished . . .	About eight .	.46	6	87	7
Pine nuts (pignolias) . .	About eighty .	.56	22	74	4
Walnuts, California . .	About six . .	.48	10	83	7
Cereals					
Bread, brown, av. . . .	Ord. thick slice	1.5	9	7	84
Bread, corn (johnnycake), av.	Small square .	1.3	12	16	72
Bread, white, homemade	Ord. thick slice	1.3	13	6	81
Corn flakes, toasted . .	Ord. cereal dish	.97	11	1	88
Corn meal, granular, av.	. . . .	.96	10	5	85
Crackers, graham . . .	Two crackers .	.82	9	20	71
Crackers, oatmeal . . .	Two crackers .	.81	11	24	65
Hominy, cooked . . .	Large serving .	4.2	11	2	87
Macaroni, cooked . . .	Ord. serving .	3.85	14	15	71
Oatmeal, boiled . . .	1½ serving . .	5.6	18	7	75
Popcorn	. . . .	.86	11	11	78
Rice, boiled	Ord. cereal dish	3.1	10	1	89
Rice, flakes	Ord. cereal dish	.94	8	1	91
Rolls, Vienna, av. . . .	One large roll .	1.2	12	7	81
Shredded wheat . . .	One biscuit . .	.94	13	4.5	82.5
Spaghetti, av.	One serving .	.97	12	1	87
Zwieback	Size of thick slice of bread . .	.81	9	21	70
Miscellaneous					
Eggs, hen's, boiled . .	One large egg .	2.1	32	68	0
Eggs, hen's, whites . .	Two whites .	6.4	100	0	0
Eggs, hen's, yolks . . .	Two yolks . .	.94	17	83	0
Omelet	Small serving .	3.3	34	60	6
Soup, beef, av.	2½ plates . .	13	69	14	17
Soup, bean, av.	Very large plate	5.4	20	10	70
Soup, cream of celery .	Two plates . .	6.3	16	47	37
Consommé	Five to six cups	29	85	0	15
Clam chowder	Two plates . .	8.25	17	18	65
Chocolate, bitter . . .	Half a square .	.56	8	72	20
Cocoa	¼ of 5¢ cake .	.69	17	53	30
Ice cream	Small brick. .	1.6	5	62	33

NOTE. — Should you desire to add further items to the preceding table, obtain Experiment Station Bulletin 28, *The Chemical Composition of American Food Materials*, by Atwater and Bryant. (Send 10 cents in coin to Superintendent of Documents, Washington, D.C.) The weight in ounces of a standard portion equals 1600 divided by number of Calories per pound given in table. The Calories furnished by protein equal the percentage of protein given in the Bulletin table multiplied by 1860 and divided by the number of Calories per pound. The same calculation and factor applies to carbohydrates. For fat, calculate the same way, but use the factor 4220 in place of 1860. Verify the three results by adding to see if they equal 100 Calories.

Daily Dietary of a First Term High School Boy

	Calories			
	Protein	Fat	Carbohydrate	Total
Breakfast				
Orange	6	3	91	
Hominy (a small serving) . .	8	1	67	
with milk 3 oz. and . .	9	26	15	
sugar (3 teaspoonfuls) .			100	
Toast, 2 slices	3	1	15	
with butter	.5	66	—	
One boiled egg	32	68		
Coffee, cream, and sugar . .	1	28	70	
	59.5	193	358	610.5
Lunch				
Cream of corn soup . . .	11	58	31	
Soda crackers (3)	15	30	105	
Bread, 2 slices	26	12	162	
Butter, $\frac{3}{4}$ pat	.4	75		
Prunes, 5 large	5	—	162	
Cup of milk custard . . .	26	56	18	
	83.4	231	478	792.4
Dinner				
Boiled mutton	35	65		
Two baked potatoes . . .	22	2	176	
Brown gravy	3	68	8	
Bread (a thin slice)	10	4	60	
Butter	.3	60		
Spinach (large serving) . .	15	66	19	
Pineapple (canned)	1		136	
with juice			40	
Molasses cookies	15	42	153	
	101.3	307	592	1000.3

Total day's dietary = 2403.2 Cal.

Method. — First make careful note of all food that enters your body during 24 hours. Not only the amount taken at meals, but all between meals, should be noted. Using the tables, arrange your data according to the preceding example.

You already know your Calorie requirement from a previous experiment. You know the proportion of Calories you need of protein, fat, and carbohydrate according to Atwater, Chittenden, and Voit. You have now worked out the actual proportion in your daily food income as shown by the 100-Calorie portion.

Conclusion. — 1. Am I eating the right proportion of protein, fat, and carbohydrate according to the standard of (*a*) Atwater, (*b*) Chittenden, (*c*) Voit? (Ask your instructor which of the above standards you should follow.)

2. What can I do to make my dietary more suited to my needs?

***Problem 177**: To compare your day's total Calories with the estimated needs of a person of your age doing the kind of work which you do.*

Method. — Check up your day's total Calories by comparing it with your requirement by body weight and by Tables 1 and 2, Problem 174.

Head your paper: Name ——, age ——, weight —— lbs.

Daily Calorie needs ——————
Amount computed ——————
Discrepancy ——————

Conclusion. — 1. How does your day's total Calories compare with that given in the table of daily needs of a person of your age, doing the kind of work you did for the day?

2. If there is any discrepancy, how can you account for it?

3. Can you suggest any improvement in your dietary?

***Problem 178**: To find the relation of the value of food to its cost in the family dietary.*

Method. — Make a careful record of all purchases of food in your home for one week. Find out what the average weekly cost is by dividing the total cost by the number in your family.

Using the table on pages 198 to 201 and your daily Calorie requirement, make out a cheap but well-balanced ration for one person for a period of one week. Multiply the result by the total number in your family. Compare the total cost thus obtained with that worked out from your home dietary.

Conclusion. — 1. Are you living as cheaply as you might?

2. What inexpensive substitutes might you introduce in place of meat?

***Problem 179**: To study some forms of food adulteration and some means of detecting adulterants.*

NOTE. — Foods are said to be adulterated when any substance is added to them to cheapen their cost. Such added materials are not of necessity unwholesome; for example, starch is added to sausage to enable the seller to make a larger profit. Some adulterants are chemical preservatives; for example, boric acid, borax, benzoate of soda, formaldehyde, and sulphurous acid. Others are coloring matters. They are used in cheaper grades of jelly, tomato catsup, canned tomatoes, pickles, peas, and beans (a copper salt is used to make them greener), and butter of a poor grade is made to look yellow, etc. Certain common frauds are easily detected by the tests which follow.

a. Test for Pure Butter

Materials. — Butter, spoon.

Method. — Put some butter in a spoon and heat it over a lamp. If it is good butter, it will boil quietly with much foam. Oleomargarine or poor butter will splutter and crackle with little foam.

Observations. — How does the butter act when heated?

Conclusion. — Is the butter tested pure?

b. Test for Adulteration in Coffee

Materials. — Ground coffee, beaker.

Method. — Place half a teaspoonful of coffee to be tested on the surface of a glass of cold water. Leave it for not more than five minutes.

Observations. — If the material sinks, leaving a brownish trace in the water as it sinks, it is chicory. If it floats for five minutes, it is coffee. What happens?

Conclusion. — Is the coffee tested pure coffee?

c. Test for Copper

Materials. — Canned peas or beans, beaker, hydrochloric acid, iron nail.

Method. — Place half a spoonful of mashed canned peas or beans in a beaker containing one spoonful of water and 10 drops of hydrochloric acid. Set the beaker in a dish of boiling water. Drop a new iron nail into the mixture. Boil for ten minutes. Stir constantly.

Observations. — What color does the nail turn? (See note, page 212.)

Conclusion. — Is copper present in the material tested?

d. Are Eggs Fresh?

Materials. — Egg, salt solution.

Method. — Make a weak (10 per cent) salt solution. Place eggs to be tested in the solution.

Observations. — Do the eggs you test float? If so, they are fresh.

Conclusion. — Are the eggs tested fresh?

e. To Test Milk for Formaldehyde

NOTE. — Formaldehyde is an unlawful adulterant.

Materials. — Milk, beaker, hydrochloric acid, ferric chloride.

Method. — Put in a beaker a teaspoonful of milk from the dairy that supplies your home or lunch room. Add twice the amount of hydrochloric acid to which a drop of ferric chloride has been added. Mix by rotating the beaker gently. Place the beaker in a pan of boiling water and leave for 5 minutes.

Observations. — If there is a purple or lavender color, formaldehyde was present in the milk.

Conclusion. — Is formaldehyde present in the milk tested?

Problem 180: *To determine the effect of alcohol upon raw white of egg.*

Materials. — White of egg, alcohol, test tubes.

NOTE. — In chemical and physical composition the white of egg is nearly like protoplasm.

Method and Observations. — Fill a test tube with raw white of egg. Pour slowly a little alcohol into the tube. What effect does it have on the white of egg? Pour in equal amounts of alcohol and of egg, and mix the two substances by shaking. What is the effect?

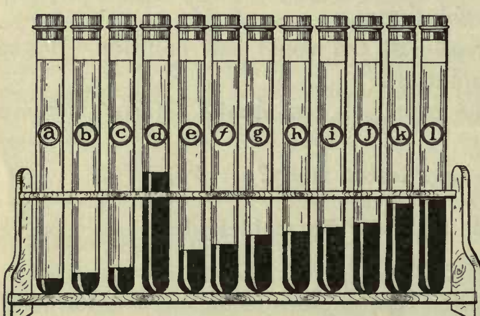
NOTE. — The alcohol takes out the water from the white of egg.

Conclusion. — What does alcohol do to white of egg? Might it have the same effect upon living matter?

Problem 181: *To determine the amount of alcohol in some patent medicines.*

Materials. — Materials shown in cut in *Civic Biology*, page 294.

Observations. — Note the percentage of alcohol (represented by the solid black) in the test tubes. A test tube represents a glass. Compare the amount of alcohol in bitters (k) as compared with a like amount of beer. Compare the amount of alcohol in tonic (j) as compared with a like amount of champagne.



Many Indians, when the sale of liquor was stopped on their reservation, began using certain patent remedies. How many glasses of bitters (k) would they have to take to get the amount of alcohol found in a glass of whisky?

Conclusion. — 1. Why are some patent medicines dangerous? 2. Why might they have a tonic effect?

Problem 182: *To test for acetanilid and to know some patent medicines containing it.*

Materials. — Headache powder, zinc chloride, test tube.

Method. — Mix a half spoonful of zinc chloride with an equal amount of some headache powder in a dry test tube. Heat slowly.

Observations. — Note the fumes. Place a match or bit of wood in the fumes. If the wood is colored red or yellow, then the medicine contains the dangerous heart depressant drug called acetanilid.

Conclusion. — 1. How would you know the presence of acetanilid in a substance?

2. Why would samples of medicines containing acetanilid be distributed free?

3. Why are such medicines unsafe to use?

Problem 183: What are the harmful materials formed in catarrh cures and soothing sirups?

Materials. — Charts, labels of soothing sirups and catarrh cures.

Method. — Using the charts made by the American Medical Association,[1] 535 N. Dearborn St., Chicago, Ill., Farmers' Bulletin 393, and the labels of various soothing sirups and catarrh cures, determine which ones contain opium, cocaine, morphine, codine, or other habit-forming drugs.

NOTE. — Many of the so-called catarrh cures or soothing sirups owe their efficacy to some of the above-mentioned drugs. The Pure Food and Drug Law requires that the labels of patent medicines tell all the ingredients therein contained.

Observations. — How many of the medicines examined contained habit-forming drugs? What kind of newspapers in your city carry advertisements of any of the above medicines? Do these papers bear a good reputation?

Conclusion. — 1. Why would working girls be likely to use catarrh cures?

2. Why do mothers give babies soothing sirup? What might be the effect on the child?

3. What would be the effect upon any one who took such drugs frequently?

[1] *The Great American Fraud*, by S. H. Adams, reprinted by the American Medical Association, has been the basis from which were made Problems 181, 182, and 183. Other problems of equal value on *Preying on the Incurable*, *The Surecure Remedies*, *The Specialist Humbug*, and *The Scavengers* may be obtained from this source and are recommended if time permits. Work of this sort is certainly practical, interesting, and worth while.

Problem Questions

1. What is a nutrient? What uses have nutrients in foods?

2. What are the differences between a food and a nutrient?

3. What is a *balanced* ration?

4. What differences should age, sex, occupation, environment, and health make in a daily dietary?

5. Why should foods be cooked? Give three reasons.

6. What is a Calorie?

7. Why is a mixed diet necessary?

8. Name five common errors in eating.

9. Of what use are inorganic nutrients?

10. Of what use are condiments and flavoring substances?

11. How do vegetable foods compare in nutritive value with animal foods?

12. How do vegetable foods compare in cost with animal foods?

13. How do beans and peas compare with meats as to cost and protein content?

14. How does fish compare with meat as to cost and protein content?

15. How do eggs and milk compare with meat as foods? How do they compare in cost?

16. How do nuts compare with meat in cost as a source of protein?

17. Compare poultry with meat as to cost and protein content.

18. Compare cheese with meat in price and protein content.

19. Would a vegetarian diet be possible from the standpoint of protein necessary to the body? How would it compare with a diet containing meat? Are there any reasons why a vegetable diet is unwise?

20. Of what use are soups as food?

21. Why do we use fruit in a daily dietary?

22. Is the use of tea, coffee, or cocoa justifiable in a daily diet? Why do people drink them?

23. Why are cheap cuts of meat cheap?

24. Defend the statement, "The average American family wastes enough in the kitchen to support a French family."

25. Is alcohol a food? Is it a poison? Can any material be both a food and a poison?

26. Do you know the pure food laws of your state? If not, procure a copy and learn them.

27. What is wrong with our present Federal Pure Food and Drug Law?

28. What is an adulteration? Does your pure food law protect you from adulteration of food?

Reports for home work are recommended in the work of this chapter. In this connection, the reports of the Department of Agriculture on various food topics are recommended. See the list of reference books which follows.

Reference Books

Hunter, *Civic Biology*, Chap. XIX. American Book Company.

Hunter, *Elements of Biology*, Chap. XXVII. American Book Company.

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XX. DIGESTION AND ABSORPTION

***Problems.** — To determine where digestion takes place by examining:—*

(*a*) *The functions of glands.*
(*b*) *The work done in the mouth.*
(*c*) *The work done in the stomach.*
(*d*) *The work done in the small intestine.*
(*e*) *The function of the liver.*

To discover the absorbing apparatus and how it is used.

Laboratory Suggestions

Demonstration of food tube of man (manikin). — Comparison with food tube of frog. Drawing (comparative) of food tube and digestive glands of frog and man.

Demonstration of simple gland. — (Microscopic preparation.)

Home experiment and laboratory demonstration. — The digestion of starch by saliva. Conditions favorable and unfavorable.

Demonstration experiment. — The digestion of proteins with artificial gastric juice. Conditions favorable and unfavorable.

Demonstration. — An emulsion as seen under the compound microscope.

Demonstration. — Emulsification of fats with artificial pancreatic fluid. Digestion of starch and protein with artificial pancreatic fluid.

Demonstration of "tripe" to show increase of surface of digestive tube.

Laboratory or home exercise. — Make a table showing the changes produced upon food substances by each digestive fluid, the reaction (acid or alkaline) of the fluid, when the fluid acts, and what results from its action.

To the Teacher. — The chief purpose of this chapter is to make plain the chemical changes that take place during the process of digestion. The experiments given have been found to be much more useful for immature minds of first-year students than a longer series of conditions, which, although necessary for the fulfillment of the technically correct experiment, are nevertheless extremely confusing to the beginner. We here deliberately sacrifice some of the factors in the experiment in order to maintain interest and obtain understanding.

The absorption of foods is a difficult subject even for the adult, so experimental work is not deeply treated. Nor should much more than memory work be expected at this time because of the several factors involved and the extreme difficulty of their control. We cannot expect our teachers, much less our pupils, to

be expert physiological chemists. But we can obtain and understand some of the data involved. It is with such an end in view that the rather curtailed lists of important happenings in the process are here outlined.

***Problem 184:** To compare the digestive system of a frog with that of man.*

Materials. — Opened frogs preserved in 4 per cent formalin, manikin showing digestive tract, opened frogs' stomachs, hand microscopes, charts of digestive systems or diagrams on page 297, *Civic Biology*.

Method and Observations. — Note in the opened specimen of the frog the glistening membrane (*peritoneum*) lining the body cavity. It is this membrane in man that becomes inflamed and causes peritonitis.

Notice the large, reddish brown organ covering most of the other organs. This is the *liver*. Count the *lobes* or divisions of the liver and compare the position and general structure with the liver of man (use manikin). Lift up the middle lobe of the liver and find the *gall bladder*, a greenish sac. This contains bile, a secretion from the liver. Now compare with the manikin to see if you can locate where the bile gets into the food tube.

The food tube begins at the mouth, continues as a short wide *gullet* into the *stomach* (just under the liver). Compare these structures in the frog with similar structures in man. The stomach of the frog leads into a long coiled *small intestine* and thence into a very short *large intestine*. What difference is there between the frog and man in this respect? Note that all the organs are held in place by a fold of the body cavity lining called the *mesentery*. What might its use be? A pinkish body, the *pancreas*, can be located between the stomach and the first bend of the small intestine.

Look at the open stomach; notice the folds and ridges on the inner wall and determine which way they run.

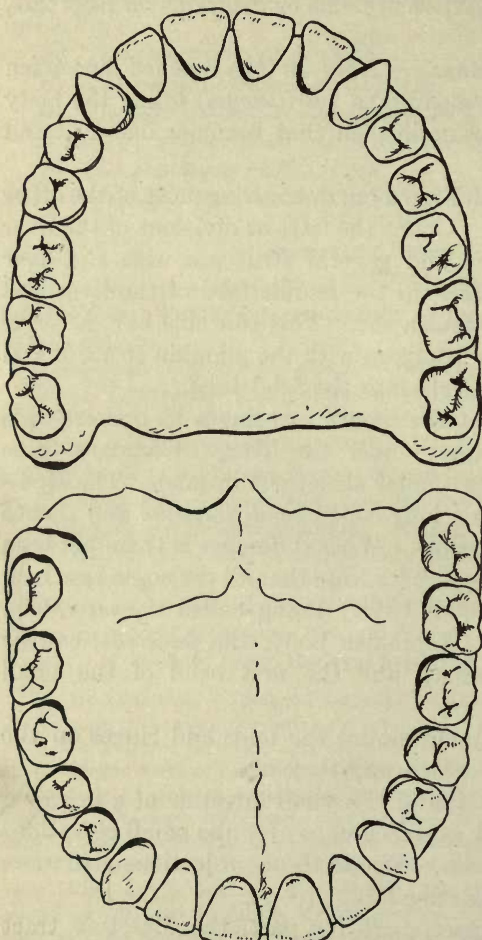
Look at a mounted section of the small intestine of a dog or a cat through a compound microscope to note the small elevations of its inner lining called *villi*. Would these projections give more surface to the small intestine?

Conclusion. — 1. Compare, part for part, the digestive tract

of a frog with that of a man. In what respects are they similar? Different?

2. Of what uses might the ridges in the stomach be? The folds and villi in the intestine? (Remember the purpose of the food tube is to prepare food to become part of the blood.)

Drawing. — Draw the food tube and glands of the frog and show all parts. On the same page, using the manikin, draw the food tube and glands of man. Label all parts of drawings.



Problem 185: To study my own teeth.

Materials. — A mirror, teeth. Figure, page 301, *Civic Biology.*

Method. — Using a small mirror, count your teeth, giving the number under each of the following heads:

(*a*) *Incisors,* broad cutting teeth in front.

(*b*) *Canines,* pointed sharp teeth next to the incisors.

(*c*) *Premolars,* grinders with two points on the biting surface.

(*d*) *Molars,* teeth with more than two points, in the back of the mouth.

Observations. — What are the numbers and uses of each of the above kinds of teeth?

Examine carefully in a strong light each of your teeth and answer the following questions, marking the points asked for on a chart of your teeth copied from the preceding diagram. 1. With a bracket, label each group of teeth. 2. With a cross, mark all the teeth you have lost or that have not grown. 3. Mark all cavities not filled in your teeth by a spot where the cavity exists. 4. If teeth have been filled, crowned, etc., mark with appropriate title.

Conclusion. — What is the condition of my teeth? Should I go to a dentist?

Problem 186: *To demonstrate the function and structure of a simple gland.*

Materials. — Fehling's solution, test tube, cracker, stained slide showing longitudinal and cross sections of a gland.

a. Function

Method and Observations. — Think of a lemon or a pickle. What happens in your mouth? Collect some of the saliva. What is its appearance?

Chew up a cracker having no sugar in it. After the mass is well mixed with saliva put in the test tube and place the tube in warm water for an hour. Then test with Fehling's solution. What is the result?

Conclusion. — 1. With what structures in the human body is a gland connected?

2. What is one function of the juice poured out by the salivary glands of the mouth?

b. Structure

Observations. — Under the microscope, notice the structure of a gland in both cross and longitudinal sections. With what is the wall lined? What is the shape of the gland? (See textbook.) If work is done by a gland, then it must have food to do this work. Might the material poured out of a gland be manufactured from the food it gets?

What structures would of necessity go to a gland to take food there? Look at the diagram in your textbook.

Conclusion. — 1. Write a paragraph telling the uses and structure of a gland.

2. Make a diagram showing the parts of a gland.

***Problem 187**: To find the use of digestion.*

Materials. — Starch paste, saliva, thistle tubes with membrane covers, Fehling's solution, lamp, battery jar containing *warm* water (about 100° F.).

Method. — In one thistle tube place some saliva mixed with starch paste. In a second tube place some paste and water. Fasten membrane covers over the thistle tubes, and wash carefully to rid of all starch or other material on outside of tube. Then place the two thistle tubes, large end down, in the jar containing warm water. Next test some saliva with Fehling's solution. Is there any grape sugar present? At the end of the laboratory period test the contents of the jar with iodine and with Fehling's solution. Was there any starch in the water? Grape sugar?

Conclusion. — 1. What caused the presence of this grape sugar in the jar?

2. How did it get into the jar?

***Problem 188**: To determine the conditions most favorable for gastric digestion.*

Materials. — Test tubes, eggs, hydrochloric acid, pepsin, caustic soda, copper sulphate.

Method. — Use five test tubes or beakers and some boiled white of egg. In No. 1, place minced white of egg and water; in No. 2, place minced white of egg and .2 per cent hydrochloric acid; in Nos. 3, 4, and 5, place minced white of egg, .2 per cent hydrochloric acid and pepsin.

Keep the first three in a warm place at about a temperature of blood heat for several hours. Keep No. 4 in an ice box or surrounded by cracked ice. Keep No. 5 in boiling water for 15 or 20 minutes, then place it in the warm place with Nos. 1, 2, and 3.

Observations. — Test No. 1 with *biuret* test[1] for the presence of

[1] Biuret solution: To the material to be tested add its own bulk of concentrated caustic soda. Then add a drop or two of weak copper sulphate solution. A violet or blue color shows the presence of unchanged protein, a rose pink the presence of peptone.

a soluble protein (a *peptone*). Test Nos. 2, 3, 4, and 5 with biuret test, noting results, and remembering that whenever there is peptone present the mixture in the test tube shows a rose pink color.

Conclusion. — 1. What conditions are necessary for the digestion of protein?

2. What is the effect of an extreme heat and cold on the action of hydrochloric acid and pepsin with a protein?

3. Make a table to give all your results of the above tests of conditions necessary for digestion of protein.

***Problem 189**: To determine another effect of gastric juice.*

Materials. — Lime and hydrochloric acid.

Method. — To a little lime add weak hydrochloric acid.

Observations. — What happens?

Conclusion. — What might be the effect of gastric juice upon certain salts taken into the body?

***Problem 190**: To note the action of pancreatic juice on starch.*

Materials. — Make some artificial pancreatic juice by mixing 5 grains of pancreatin and 10 grains of baking soda in 100 c.c. of water, Fehling's solution.

Method. — Add some of this artificial pancreatic juice to some dilute starch paste. Keep at about body temperature for a few hours, then test with Fehling's solution.

Observations. — What occurred when Fehling's solution was added?

Conclusion. — What was the action of pancreatic juice on starch?

***Problem 191**: To note the effect of pancreatic juice on oils and fats.*

Materials. — Test tube, oils, baking soda.

Method. — Shake up oil and water. What happens? Then add a little alkaline substance, *e.g.*, baking soda. What happens? Now shake up water with artificial pancreatic juice. What happens?

NOTE. — An emulsion is formed by breaking fats up into very small droplets which float in a liquid, making a milky appearance. In addition to emulsifying

fats, pancreatic juice changes them into soft soaps and fatty acids. Fat in this form may be absorbed. (See page 306, *Civic Biology*.)

Conclusion. — 1. What conditions are necessary to make an emulsion?

2. What is the effect of pancreatic fluid on oils?

Problem 192: To study the effect of artificial pancreatic juice on protein.

Materials. — Artificial pancreatic juice, caustic soda, copper sulphate.

Method. — Using artificial pancreatic juice *instead* of a mixture of hydrochloric acid and pepsin, carry out an experiment as described for tube No. 3 of Problem 188.

Observations. — Was any of the white of egg digested?

Conclusion. — Make a table to show the effect of pancreatic juice on nutrients.

Problem 193: To find one action of bile.

Materials. — Ox gall or bile, olive oil, parchment paper, funnels.

Method. — Take two funnels, place parchment paper in each. Moisten one paper with bile, the other with water. Then place an equal amount of olive oil in each funnel.

Observations. — Through which funnel does the oil pass more freely?

Conclusion. — What effect might bile have on the wall of the intestine?

Summary of the Uses of Human Food Tube and Glands

DIGESTIVE SYSTEM OF MAN

- Alimentary Canal and Digestive Glands
  - Mouth
    - Teeth
    - Tongue
    - Glands — saliva — digests starch
  - Pharynx.
  - Esophagus
  - Stomach—glands—gastric juice—digests proteins—dissolves lime salts
  - Small intestine—glands
    - Liver — bile — helps fat absorption
    - Pancreas—pancreatic juice—digests
      - starch
      - protein
      - oils
    - Absorption of digested foods
  - Large intestine — slight absorption of soluble foods and wastes

Fill out a diagram like the following:

Glands	Location	Juice	Enzymes or Ferments	Action of	Result of its Action	How test for Action

***Problem 194**: To study the method and place of absorption in the human body.*

NOTE. — Absorption is the process by which digested food passes from the digestive canal through the walls of the blood vessels into the blood.

Materials. — Tripe, slides showing villi, charts.

Observations. — Study the structure of tripe (stomach wall) and the microscopic slide of a cross section of the small intestine. Remember that the chief function of the small intestine is to get food into the blood.

Make a tube of paper having a diameter of 1 inch. Then try to make a tube having the same diameter but having a folded wall. Which takes more paper? Which would present more surface?

Conclusion. — How is the structure of the wall of the intestine fitted for absorption?

***Problem 195**: To understand the structure of a villus.*

Method. — Study the figure of the villi on page 307, *Civic Biology;* make sure you understand the use of each part.

Conclusion. — 1. If blood goes into the villus, what change in its composition might take place within it?

2. How do fats get into the villi? What becomes of the fats?

***Problem 196**: How may foods be absorbed by the villi?*

Observations. — Suppose the villus is lined with a delicate skin-like covering. How might liquid food pass through? Suppose movements of other organs should press upon or squeeze the

intestines. Would any food be forced through? Might fluids pass through in the same way as a sponge absorbs water?

Conclusion. — In what ways is liquid food absorbed?

***Problem 197:** To find the pathway of absorbed foods.*

Method. — Study the diagram on page 309, *Civic Biology;* remember that digested food is within the intestine. Follow the course of sugars and digested proteins as far as the heart. What happens to the blood vessels in the liver?

NOTE. — Sugar is taken from the blood and stored as animal starch (*glycogen*) in the liver and muscles. Fat during the process of digestion by the pancreatic juice is split into fatty acids and glycerin and is absorbed as such. In the villi, these fatty acids and glycerin are rebuilt into small fat particles. They pass through the lymph capillaries, called the *lacteals,* which empty into the thoracic duct and thence into the heart and circulation.

Conclusion. — 1. Write a brief paragraph summarizing the different pathways by which food reaches the heart and general circulation.

2. Complete the following table:

Foods	Where Absorbed	Form	Adaptations for	Paths to Heart

PROBLEM QUESTIONS

1. What are the uses of (*a*) the incisors, (*b*) the canines, (*c*) the premolars, and (*d*) the molars?
2. How many teeth are there in our first set of teeth? When do they begin to come, and when do they go?
3. What makes teeth decay?
4. Why should we clean the teeth night and morning?

5. What harm might come from swallowing fluids which pass through a mouth containing decayed teeth?

6. How often should one visit the dentist? Why?

7. How does the practice of Fletcherism help digestion?

8. What is a gland? What work does it do?

9. What are the digestive glands of the human body?

10. Tell where each part of a meal of bread and butter, meat, rice pudding, and nuts is digested.

11. Why should we chew starchy foods well before swallowing?

12. Why is soup eaten at the beginning of a meal? (Remember it is absorbed rapidly.)

13. Why are partly cooked foods harder to digest than well-cooked foods?

14. Name three easily digested foods and tell why they are easy to digest.

15. Name three foods difficult to digest and tell the reasons why.

16. Give, in detail, the digestion of a meal of milk, apple sauce, and bread.

17. Where is food absorbed?

18. How is food absorbed?

19. Why is it necessary that food be absorbed?

20. Where and how do fats get into the blood?

21. What happens to fats before they get out of the intestine? Before they get out of the villus?

22. Why do salt and water need no digestion?

23. What changes take place in the composition of blood in the walls of the small intestine? In the walls of the stomach? In a gland? In the liver?

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XXI. THE BLOOD AND ITS CIRCULATION

***Problems.** — To discover the composition and uses of the different parts of the blood.*

To find out the means by which the blood is circulated about the body.

Laboratory Suggestions

Demonstration. — Structure of blood, fresh frog's blood and human blood. Drawings.

Demonstration. — Clotting of blood.

Demonstration. — Use of models to demonstrate that the heart is a force pump.

Demonstration. — Capillary circulation in web of frog's foot or tadpole's tail. Drawing.

Home or laboratory exercise. — On relation of exercise on rate of heartbeat.

To the Teacher. — To prove that blood contains liquid food and to show how blood is made are the first considerations in this chapter. The uses of the corpuscles may well be shown in part by experiment. Proof of circulation of the blood centers around two experiments: evidence that the heart is a force pump and the demonstration of capillary circulation in the tadpole's tail. Interesting and vital laboratory work may be done by comparing graphs of the heartbeat of members of the class when at rest, after mental work, and after physical work. Interesting correlations between physiologic age, sex, and rate of heartbeat may also be worked out. The importance of ferments in the blood is a new and fascinating topic to which time should be devoted if materials are available to the teacher.

***Problem 198:** To prove that blood contains nutrients.*

Materials. — Ox blood, nitric acid, ammonia, Fehling's solution, formalin, iodine, test tubes, lamp, egg beater.

Method. — Collect some blood at a slaughter house. Set aside one bottle to clot (label it clotted blood). Place some of the fresh blood in a flat bowl and beat it with an egg beater. Fill a bottle with the red liquid (label it defibrinated blood). After washing, place the *fibrin*, or threads which stick to the egg beater, in a third bottle. Pour 4 per cent formalin on the fibrin to

preserve it. We have said that blood is made, in part at least, of digested foods. In the bottle containing the clotted blood notice the solid part, the *clot*, and a yellowish liquid called *serum*.

Pour off some of the serum into each of three test tubes.

Test the first with iodine solution. — Result?

Test the second with Fehling's solution. — Result?

Test the third with nitric acid and ammonia. What is the result?

Test some of the blood fibrin with nitric acid and ammonia.

Observations. — Note what happens in each of the three tubes. What is fibrin?

Conclusion. — 1. What nutrients are present in blood serum?

2. Of what is fibrin composed?

3. What nutrients are present in blood?

NOTE. — The blood clot is composed in part of structures (largely protein) known as *corpuscles*. These can better be seen in prepared specimens under the compound microscope.

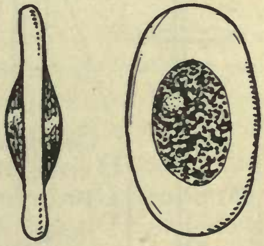
Problem 199: To study the corpuscles of the blood.

a. In Frog

NOTE. — Blood is composed of two principal parts, solid bodies (*corpuscles*) and a liquid (*plasma*).

Materials. — Frogs, glass slide, cover glasses, microscope.

Method. — Place some frog's blood on a glass slide, cover and examine under a compound microscope. (See figure.)



CORPUSCLE OF FROG.

Observations. — What are the color and shape of the corpuscles that are most numerous and most easily seen? These are *red corpuscles*.

There are other irregular-shaped corpuscles, more transparent and not so easily seen. These are the colorless corpuscles.

Conclusion. — 1. What kinds of corpuscles did you find?

2. Are corpuscles *cells?* Can you prove your statement?

b. In Man

Observations. — Using a slide of your own blood, note that red corpuscles have no nucleus. (They do when they are young.) Are they cells? Do you find colorless (white) corpuscles as well? How do they compare with the red in number?

Corpuscle of Man.

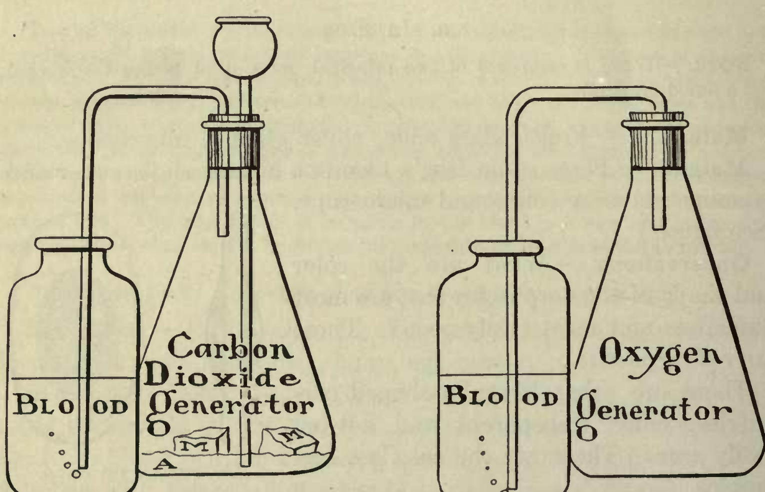
Conclusion. — How does the structure of blood corpuscles in man compare with those of the frog?

The following experiment will show one of the functions of corpuscles.

***Problem 200**: To determine the effect of oxygen and carbon dioxide upon the blood.*

Materials. — Test tubes, defibrinated blood, calcium carbonate, hydrochloric acid, oxone.

Method. — Using two tubes of defibrinated blood, lead a tube from a bottle containing calcium carbonate and hydrochloric acid into one tube. This will produce carbon dioxide gas. Lead a



Apparatus for Generation of Carbon Dioxide and Oxygen.

A, acid; *M*, marble.

tube from a stoppered bottle containing a little piece of oxone (which gives off oxygen) into the second tube.

Observations. — Note the change of color in both test tubes. The change from a deep purple to a scarlet occurs in the lungs as blood passes through them.

Conclusion. — 1. How can we know of the presence of oxygen in the blood? Of carbon dioxide?

2. How and when would carbon dioxide get into the blood? (Remember the cells of the body do work.)

NOTE. — The red corpuscles contain a substance known as *hæmoglobin* which readily unites with oxygen. When the corpuscles take up oxygen, their color changes to a brighter red.

3. How is the oxygen carried in the blood?

Problem 201: To study the structure of the heart.

Materials. — Model of a human heart, beef heart (opened), and charts.

Method. — Refer to chart of circulation, page 321, *Civic Biology.* Find the heart, arteries, and veins connected with it. Find out where the chief arteries lead and from where the large veins come. Also examine a beef heart or a good model and note the four chambers, the valves, and the blood tubes leading to and from it.

NOTE. — The upper chambers (see model) are called the right and left *auricles* respectively; the lower chambers the right and left *ventricles.*

Observations. — Which have the thicker walls? What is probably the use of these walls? Notice the position of the valves and the direction of their movement. In what direction do arteries lead? Veins? Into how many chambers is the heart divided? Do these chambers *all* connect with one another? Can you find a solid wall between the right and left sides? Can you show the heart to be a double force pump? Where does the right side of the heart send the blood? The left?

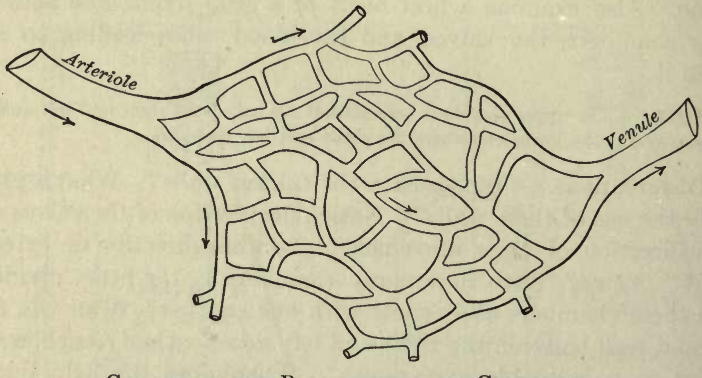
Conclusion. — Write a paragraph describing the structure of the heart.

Drawing. — Make a drawing from the model. Label all parts.

***Problem 202**: To study the circulation of the blood.*

Materials. — Living tadpole under influence of a 1 per cent solution of chlorotone, mounted on a piece of board having a ½ inch hole bored in one end. Place the thin part of the tadpole's tail over the opening; keep the tadpole moist by wrapping it in wet cotton. (The fin of a living goldfish or the web of a frog's foot may be used.)

Observations. — Observe the network of small blood vessels containing moving disks, the *corpuscles*. In some of the tubes the blood appears to move in spurts. These tubes are *arteries* and lead from the heart. Trace the tiny arteries in the direction the blood flows and notice they divide into very small tubes called *capillaries* which connect the arteries with tubes called *veins*. The latter lead back to the heart. How does a capillary differ from a small artery or a small vein? Does the blood flow in an artery differ from the flow in a vein? Describe the disk-like bodies (red corpuscles) in the blood. How do they compare in size with the diameter of the capillary tube? Make a copy of the following diagram in colors, labeling all parts, showing blue for veins, purple for capillaries, and red for arteries.



CHANGES IN THE BLOOD WITHIN THE CAPILLARIES.

Conclusion. — 1. How does blood get from arteries into the veins? 2. What change might take place on the way? Why? 3. What causes the pulsation (pulse) in the arteries?

Problem 203: To determine the rate of your own heartbeat.

Method. — Take your own pulse by placing the fourth finger of your right hand on the left wrist, just at the base of the thumb about one inch up on the wrist; or place the finger on the side of the head just in front of the ear. After getting the pulse, wait for a signal, then count the number of beats for one minute. Give your age and rate of your pulse per minute to a pupil chosen to place the returns from the class on the board arranged "by age." Classify boys and girls separately.

Rate of Pulse

Age	60-65	66-70	71-75	76-80	81-85	86-90
12.6						
13.						
13.6						
14						
etc.						

Conclusion. — 1. From this table make a graph that will show the normal heartbeat of the pupils of your class.

2. Does sex have anything to do with the rate?

3. Does age?

Problem 204: What is the effect of hard mental work on the pulse beat?

Method. — Under the direction of the teacher do some hard problems in arithmetic for about five minutes. Now count pulse as before and tabulate.

Conclusion. — Does mental work affect the heartbeat?

Problem 205: What effect has exercise on the heartbeat?

Method. — Under the direction of a leader, take a hard setting-up drill for three minutes with the windows open. Count the pulse beats as before and tabulate. Also note any difference in respiration.

Conclusion. — 1. What effect does exercise have on the rate of the heartbeat? Can you explain the reason?

2. Can you explain the difference in the rate of respiration?

3. Make two graphs superimposed on the original graph (Problem 203), using different colors to indicate the difference between the normal and the other results found in the subsequent experiments.

Summary of Circulatory System

Fill in the following outline.

SUMMARY OF BLOOD

- Blood
  - Plasma
    - serum
      - water
      - digested food
      - waste products
    - fibrin
  - Corpuscles
    - red corpuscles
    - white corpuscles

Materials	Source	Destination	Constituent part of Blood

Fill out the above table and account for each part of the blood.

***Problem 206**: How to stop the flow of blood in case of an accident.*

Method. — Decide first whether the blood is issuing from an artery or from a vein. How would you know? Then apply a tourniquet made from a stick or ruler and a handkerchief or towel, using a stone or knife to press down on the blood vessel. Apply between the heart and the cut.

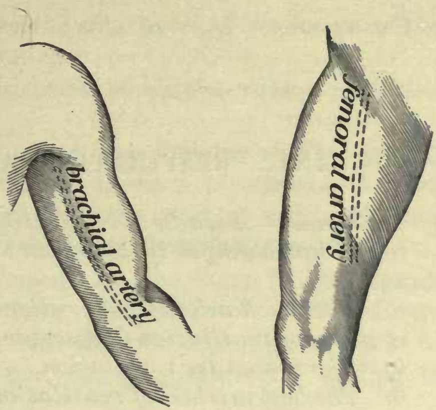
Imagine the arm to be severed below the elbow and practice applying a tourniquet on the brachial artery; on the femoral

artery. Does the pulse stop when the tourniquet is applied? Explain reason.

Conclusion. — 1. How would you go to work to make a tourniquet? Describe fully.

2. Where must a tourniquet be placed when an artery is cut? Where when a vein is severed?

3. What is the use of the tourniquet?



Problem Questions

1. What proof have we that the blood contains nutrients?
2. Is the blood a tissue? Give reasons.
3. What effect has oxygen upon the blood? What causes this?
4. Why is the heart a force pump?
5. Why is the heart said to be double?
6. Why does the blood circulate?
7. What are the chief differences between veins, arteries, and capillaries?
8. What factors may cause differences in the rate of heartbeat?
9. Explain what we mean by *the second wind.*
10. Explain why a man becomes *winded* in a hard race.
11. What factors might injure the heart? Give reasons.

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XXII. RESPIRATION AND EXCRETION

Problems. — *A study of respiration to find out:*

(*a*) *What changes in blood and air take place within the lungs.*

(*b*) *The mechanics of respiration.*

A study of ventilation to discover:

(*a*) *The reason for ventilation.*

(*b*) *The best method of ventilation.*

A study of the organs of excretion.

Laboratory Suggestions

Demonstration. — Comparison of lungs of frog with those of bird or mammal.

Experiment. — The changes of blood within the lungs.

Experiment. — Changes taking place in air in the lungs.

Experiment. — The use of the ribs in respiration.

Demonstration experiment. — What causes the filling of air sacs of the lungs?

Demonstration experiment. — What are the best methods of ventilating a room?

Demonstration. — Best methods of dusting and cleaning.

Demonstration. — Beef or sheep's kidney to show areas.

To the Teacher. — Respiration, especially, gives ample opportunity for simple experiments which can be performed by the pupil. The changes of blood within the lungs are easily demonstrated by any pupil. The mechanical factors in respiration are easily shown.

The subjects of ventilation and proper care of the home give innumerable opportunities for practical experiments by the pupils. Care must be taken, however, that the pupils do not gain wrong impressions from experiments on the burning of the candles within a box. Recent investigations make it seem certain that carbon dioxide as a factor in ventilation is less to be reckoned with than the humidity and heat factors. Experiments with wet and dry bulb thermometers should be tried in closed rooms to show the increase in the water content of air and its effect upon the human organism. Other experiments will doubtless commend themselves.

Experiments to show proper methods of dusting and cleaning should be tried at home and reported upon by groups of pupils. In this way more ground may be covered in a given time and more individuals interested in the work.

***Problem 207**: To compare the structures of the lungs of the frog and of man.*

Materials. — Freshly killed frogs, blowpipes, charts or models of human lungs.

Method. — Open a frog's mouth and find the slitlike opening (*glottis*) just back of the tongue. Insert a blowpipe or a glass tube and blow down the short windpipe (*trachea*) which branches into two divisions leading to the lungs (*bronchial tubes*).

Observations. — What happens to the lungs? Examine a section cut through a frog's lung. Is it hollow? Now compare the baglike lungs of the frog with the more complicated lungs of man (see chart). Do you find the same structures leading to the lungs of man?

NOTE. — **The windpipe divides as in the frog, one tube going to each lung. The tubes now divide like the branches of a tree in smaller tubes (the *bronchial tubes*) which end in grapelike masses of small thin-walled sacs called *alveoli*.**

Which part of the lungs of man would be elastic? Of the frog? Why?

If blood vessels were found in the walls of these sacs, what gas might be brought in the blood to this point? What gas might be in the air? How might the exchange of these gases take place? Where might it take place?

Conclusion. — 1. How do the frog's lungs differ from those of a man?

2. Explain how the structure of the lungs gives a large area of moist membrane separating the blood on the one hand from the air on the other.

3. What is in the blood that might get to the air?

4. What is in the air that might get into the blood?

***Problem 208**: To determine changes that take place in air in the lungs.*

NOTE. — **Changes have already been noted that take place in blood within the lungs. Our next problem is to see what changes take place in air within the lungs.**

Materials. — Thermometer, glass plate, limewater, glass tubing, test tube, glass jar, diagram, page 334, *Civic Biology*.

Observations. — Breathe on the bulb of a thermometer and re-

cord any changes. Breathe gently on any glass or polished metal surface. Note what happens.

Take a moderate breath, and force air (tidal air) by means of a glass tube through limewater. Notice what occurs. Note diagram.

Force the last part of a deep expiration (reserve air) through limewater. Note result.

Fill a glass jar with expired air by the downward displacement of water. Invert the jar, keeping it covered. Remove the cover, and introduce into the jar a lighted pine splinter. Does it continue to burn? What does this indicate? Why? (Air loses about one fourth of its oxygen while in the lungs.)

Conclusion. — 1. What are the changes that take place in blood in the lungs?

2. What does air gain in the lungs? What does it lose?

3. What is one reason for deep breathing?

Problem 209: *To find the capacity of the lungs.* (After Davison.)

Materials. — Gallon bottle, cork, curved glass tubing, and a large pan.

Method. — Fill the bottle with water, place water in the pan, and invert the bottle in the pan. Remove the cork, insert the end of the tubing under the bottle, fill the lungs to the fullest capacity, and force air into the bottle.

Observations. — How much water flows from the bottle? What has taken place? Place a mark on the bottle so as to show the point to which you drove out the water by means of air. Now with a graduate fill the bottle with water to the point displaced. Measure the amount of water.

Conclusion. — How much air do you conclude your lungs can hold if 100 cubic inches remain in the lungs after you have expelled all you were able? Remember a gallon contains 231 cubic inches.

Problem 210: *To study the mechanics of respiration.*

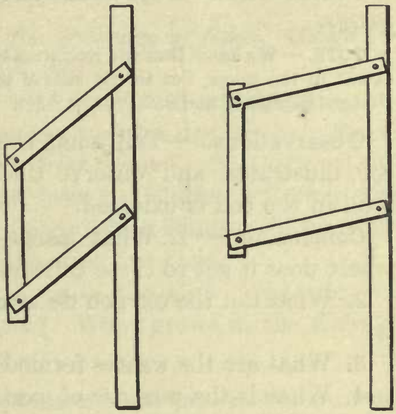
Method and Observations. — Notice the movements of the body when inhaling and exhaling in an ordinary breath and an

extra deep breath. Place your hand on your chest and take a deep breath. What happens to the ribs?

Conclusion. — Does taking in air (*inspiration*) require greater effort than sending it out (*expiration*)? Explain.

Problem 211: To study the part the ribs play in respiration. (Modified from Eddy's *General Physiology*.)

Method. — Using some strips of heavy cardboard and four paper fasteners, construct a model as shown in the left-hand figure. The largest strip of cardboard represents the backbone. Parallel to it is the breastbone or sternum. The cross pieces are two of the ribs.



Observations. — What happens to the distance between the backbone and the sternum of our model when the muscles raise the ribs to a horizontal position as shown in the right-hand figure?

Conclusion. — What happens to the capacity of the chest cavity when the ribs are raised?

Problem 212: What is the function of the diaphragm?

Materials. — Small bell jar with opening at top for rubber cork containing one opening, Y tube, balloons, and rubber sheet arranged as shown on page 333, *Civic Biology*.

Method. — The glass tube represents the trachea; the branches, the bronchial tubes; the balloons, the lungs; the rubber sheet, the diaphragm; and the walls of the chest cavity are represented by the sides of the glass bell jar.

Observations. — Lower the diaphragm by pulling the rubber sheet downward. What is the effect on the air capacity of the jar when the rubber is pulled down?

Conclusion. — 1. What makes the balloons expand?

2. Write a statement comparing the action of the rubber sheet with that of your own diaphragm. (Remember that the action of ribs and diaphragm tends to make the chest cavity larger during an inspiration.)

3. Explain fully *why* the lungs expand.

4. Explain the figure on page 331, *Civic Biology*, and make a summary of all the changes both in the blood and in the lungs.

***Problem 213**: To find out what becomes of the oxygen in the lungs.*

NOTE. — We know that the oxidation of food does not take place to any great extent in the lungs, but in the cells of the body where work is done. (See *Civic Biology*, pages 331 and 332.)

Observations. — Tell what the figure on page 332, *Civic Biology*, illustrates, and observe the wastes that are given off after food in the cell is oxidized.

Conclusion. — 1. What carries the oxygen to the cells and where does it get to these carriers?

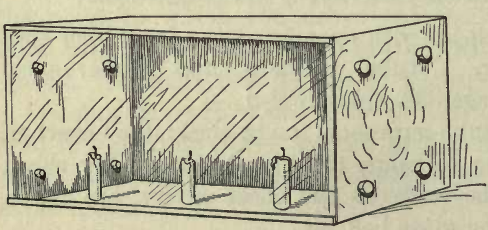
2. What did the oxygen do after it got near the cell that needed it?

3. What are the wastes formed when oxidation takes place?

4. What is the purpose of oxidation?

***Problem 214**: To make a study of ventilation.*

Materials. — A grooved box 8 × 10 inches at base, 8 inches high, with sliding glass door. Place on side and have 4 half-inch holes, two at top and two at bottom, bored in each end and fitted with corks.



Method. — Place three candles in the box as shown in the accompanying figure. Light the candles so as to use up the oxygen.

Observations. — With all the corks in place, how long (take exact time) do the candles burn?

Remove the upper corks from both ends. How long do the candles burn?

Remove the lower corks. How long do the candles burn?

Remove one upper and one lower cork from one end. How long do the candles burn?

Conclusion. — 1. What is the best method of ventilating a room?

2. Make cross-section sketches and explain the different trials. Use dotted lines and arrows to represent the course of the air.

***Problem 215**: To study air for presence of dust.* (Home Experiment.)

Materials. — Pan, Petri dish with sterile culture medium.

Method. — 1. Sweep a rug vigorously with a dry broom. Brush your clothes hard after returning from school. 2. Place an uncovered pan of water where a draft from the window will blow over it. 3. Place a sterile culture in Petri dish on window sill for a few moments and then cover; examine after five days.

Observations. — What do you see in the air? What do you notice on the surface of the water? What grows in the dish?

Conclusion. — What is in the air?

NOTE. — A home experiment with culture media to find out dust conditions in different parts of a city would be of much interest for extra credit work. Suggested places for exposure of Petri dishes would be (*a*) a dirty street; (*b*) a well-swept and watered street; (*c*) a city park; (*d*) a city market; (*e*) a workshop; (*f*) the top of a tall building. Determine by means of colonies formed in the plate the relative numbers of bacteria (and probably the dust content of the air).

***Problem 216**: To determine the best method of cleaning a room.*

Materials. — Culture dishes, dry broom, cloth, carpet sweeper, vacuum cleaner. Use four adjoining schoolrooms in which the dust is approximately the same. Expose culture dishes in each room a given length of time, say two minutes, while sweeping. Sweep room 1 with a dry broom, room 2 with a broom over which a wet cloth has been fastened, room 3 with a carpet sweeper, and in 4 use a vacuum cleaner. Place each exposed dish under the same conditions and examine after 2, 3, 4, and 5 days.

In which dish has the greatest number of colonies developed?

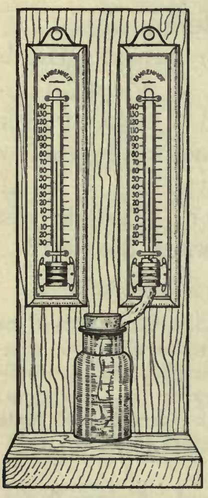
Conclusion. — 1. In which room was the most dust (and bacteria) stirred up?

2. What do you consider the best method of cleaning a room?

Problem 217:* *What makes a crowded, closed room uncomfortable?

NOTE. — It has recently been discovered that other factors besides the presence of carbon dioxide in the air of a room make it uncomfortable. A little thought on the following questions will convince you of this.

Observations. — When a candle burns, what is given off besides carbon dioxide? When a number of people are in a closed room, what then would be given off from their bodies?



A WET AND DRY BULB THERMOMETER.

NOTE. — The use of a wet and dry bulb thermometer in a closed room containing people will show a decided increase in the water content (humidity) of the air.

Where does this water come from? In what condition does it get into the air?

What is your normal temperature? Is that the temperature of the air of the room? What three substances are given off from human bodies that might affect the air of a closed room? Are you more comfortable on a hot humid day or on a hot dry day? What similar condition exists in a closed room?

NOTE. — The close odor noticeable in a closed room containing people is due to certain organic wastes given off from the body into the air.

Conclusion. — What factors cause discomfort in closed rooms where there are many people?

Problem 218:* *To study the structure of the kidney.

Material. — A sheep kidney.

Method and Observations. — An idea of the internal structure of the kidney of man may be gained by examination of a sheep's

kidney. Get the butcher to leave the mass of fat around the kidney. Of what use might this fat be? Notice, after removing the fat, that the kidney appears to be closely wrapped in a thin coat of connective tissue; this is called the *capsule.* Remove the kidney from this capsule. Notice its color and shape. The depression called the *hilum* is deeper than the corresponding region in the kidney bean. The hollow tube passing out from this region is called the *ureter.* Blood vessels also enter and leave the kidney at the hilum. Cut the kidney lengthwise into halves. Try to find the following regions: (1) the outer or *cortical region;* note its color; (2) the inner or *medullary* layer; this layer is provided with little projections; these are the *pyramids of Malpighi*, so called after their discoverer, Marcello Malpighi, a celebrated Italian physiologist; (3) the cavity or *pelvis* of the kidney. At the summit of each pyramid is a small opening through which escapes into the pelvis the secretion formed in the little *tubules* in which the real work of excretion is performed.

Conclusion. — 1. Where is the waste taken from the blood in the kidney? (Study the diagram on page 341, *Civic Biology.*)

2. Where does this waste pass out of the body?

Problem 219: The skin as an organ of excretion and heat control.

Materials. — Model of human skin in section, thermometers, hand lens, jars, scales.

a. Structure

Method. — Examine the model of a cross section of skin. Locate (using your *Civic Biology,* page 342) the epidermis, dermis, sweat glands, oil glands, nerves, and blood vessels.

Observations. — Where is the epidermis and what structures does it contain? Examine the surface of your skin with a hand lens. What structures are found in the dermis?

Conclusion. — How might the above-mentioned structures be of value to the body?

b. Functions

The above question may be answered in part by the following experiments made at home or in the laboratory.

1. **Method.** — Insert your hand in a clean, *dry* fruit jar. Wrap a towel over the opening of the jar so as to allow no air to get in between your hand and the sides of the jar.

Observations. — What happens in the jar?

Conclusion. — What is given off from the hand?

2. **Method.** — Weigh yourself. Note the weight. Exercise violently for half an hour; weigh yourself again. Note the weight.

Observations. — Was there any change in weight?

Conclusion. — How must the change of weight have been brought about and how did the body lose this? Remember that when oxidation of food or tissue takes place in the body three products, at least, are formed: heat, organic wastes, and water.

(Food + oxygen = carbon dioxide + water + organic wastes + heat + muscular energy.)

3. **Method.** — Take the temperature of the body before and after exercise by placing a clinical thermometer in the mouth. Any change? Account for this by the following experiment.

4. **Method.** — Take two thermometers, place a damp cloth around the bulb of one and leave the other exposed without a damp cloth. After some time, so as to allow the water in the cloth to reach the same temperature as the air in the room, read the two thermometers.

Income of blood	Organ	Outgo of blood to
	Alimentary Canal 9/10 from Small Intestine	
	Tissues Muscle, Nerve, bone etc.	
	Liver	
	Lungs	
	Kidneys	
	Skin	

Observations. — Do they both read the same? How do you account for the difference? Remember that when water evaporates, it takes heat from the air surrounding it.

Conclusion. — Applying this principle to the skin, explain why evaporation from the skin makes us feel cooler.

General Conclusion. — Explain the functions of the skin in the light of the above experiments.

The skin as an organ of sensation will be treated later.

Fill out the foregoing summary of changes taking place in blood within the organs of the body.

Problem Questions

1. How are the lungs fitted to do their work?
2. How is oxygen of use to the body?
3. Show two means by which oxygen is taken into the lungs.
4. Why should we practice deep breathing exercises each day?
5. What habits of bad posture harm the lungs? Explain your answer.
6. What changes take place in the blood within the lungs?
7. What changes take place in air within the lungs?
8. What is given off in the air from the lungs as a result of oxidation?
9. What is oxidation? Where does it take place in the human body?
10. Show exactly how oxygen reaches the cells of the body.
11. What does a cell do as a result of oxidizing food?
12. Why should people sleep with windows open?
13. Make a diagram to show how to ventilate a room.
14. How would you ventilate through a window without making a draft?
15. Can you explain the school system of ventilation? Is it a good one? (Remember that hot air rises and takes up with it carbon dioxide.)
16. Explain the advantage of using damp sawdust when sweeping.
17. How would you prevent dust in a sleeping room? In a schoolroom?
18. Which is cleaner, a paved or an unpaved street? Why?
19. Why is street sprinkling a good thing?
20. Which is most cleanly: a lamp, gas, or electricity? Why?

21. What are the advantages of the vacuum cleaner over other forms of sweepers?

22. How can you tell when the air of a room becomes bad?

23. Why should considerable water be drunk every day?

24. Of what use is perspiration to the body?

25. How would you keep the skin clean?

26. Give facts to prove that the skin gives off waste products.

27. What is the relation of the heat of the body to work done by the body?

28. What is the physiological use of (*a*) the cold bath, (*b*) a moderate bath, and (*c*) a hot bath?

29. Why do we feel more oppressed on a hot humid day than on a hot dry day?

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XXIII. BODY CONTROL AND HABIT FORMATION

Problems. — *How is body control maintained?*
(*a*) *What is the mechanism of direction and control?*
(*b*) *What is the method of direction and control?*
(*c*) *What are habits? How are they formed and how broken?*
(*d*) *What are the organs of sense? What are their uses?*
(*e*) *How does alcohol affect the nervous system?*

Laboratory Suggestions

Demonstration. — Sensory motor reactions.

Demonstration. — Nervous system. Models and frog dissections.

Demonstration. — Neurones under compound microscope (optional).

Demonstration. — Reflex acts are unconscious acts; show how conscious acts may become habitual.

Home exercise in habit forming.

The senses. — *Home exercises.* — (1) To determine areas most sensitive to touch. (2) To determine or map out hot and cold spots on an area on the wrist. (3) To determine functions of different areas on tongue.

Demonstration. — Show how eye defects are tested.

Laboratory summary. — The effects of alcohol on the nervous system.

To the Teacher. — The purposes of the following exercises are first, to show the pupil that he is dependent upon his organs of sense in order to interpret what goes on about him, thus to get in touch with the factors of his environment; second, to give him a glimpse of the great complexity of the mechanism and complicated structure we call the nervous system; third, to show him how habit might be evolved and the part habit plays in our daily life; and lastly, a slight conception of the workings of the organs of sense, as shown by experimental psychology.

Problem 220: *How are we aware of the world about us?*

Materials. — Needle, ether or freezing mixture for local anæsthesia, various substances having distinct taste.

Method and Observations. — Touch a flat and a rough surface with the finger tips.

Prick yourself with a needle. Then place a drop of ether or freezing mixture on the same finger and prick it. Do you still feel? How do you explain the difference?

Close your eyes and allow some one to place bits of various substances on your tongue. Can you distinguish between the different substances?

Look at this page. How do you get your knowledge of what is on this page?

At how great a distance can you hear a watch tick?

Conclusion. — Through what organs do we become aware of the world around us?

Problem 221: *To determine what parts of the body are most sensitive to (a) touch, (b) heat and cold.*

a. Touch

Materials. — Compass.

Method and Observations. — Blindfold a pupil. Then lightly touch the back of his hand with the two points of a compass. Begin with them close together and gradually move them apart. Have the blindfolded subject tell as soon as the points appear to the touch as two. Experiment further on different parts of the body, and record the results in the form of a table.

	Place Touched	Distance between Points
Back of Hand		
Palm of Hand		
Finger Tips		
Wrist		
Upper Arm		
Back of Neck		
Back		

Conclusion. — Which part of the body seemed most sensitive to touch?

b. Heat and Cold

Materials. — Large wire nail, pen, ink, and ruler.

Method and Observations. — With a ruler and a pen, draw a square inch on the under side of your wrist. Heat a wire nail so

it feels very warm. Now lightly touch all parts of the skin within the square area. Do all parts feel the heat, or only the sense of slight pressure of the nail? Mark with a little cross all spots that are sensitive to heat.

Now cool off the nail by placing it on ice. Wipe it dry and apply while still cold in the same way to the area marked off on the wrist. Do you feel the sensation of cold in all spots? Mark as before, this time using a dot.

NOTE. — Certain sense cells of the body are sensitive to heat, others to cold.

Conclusion. — 1. Do these sense cells occupy the same area? 2. Do all parts of the skin feel heat and cold?

Problem 222:* *To study the anatomy of the nervous system.

Materials. — Frogs preserved in formalin, with body cavity opened and viscera removed, scissors, scalpels, forceps, hand lens, charts showing nervous system of man, model of brain of man.

Method. — In a frog from which the organs of the body cavity have been removed, note white glistening cords (*nerves*) which seem to come from under the backbone. Follow the course of some of the larger nerves. Where do they lead? Now turn the frog over and with sharp scissors and a scalpel remove *very carefully* the bony covering (the *skull*) from the whitish body (the *brain*).

Observations. — How many parts do there appear to be in the brain? Notice the white elongated hemisphere of the fore brain or *cerebrum*. The two anterior projections of the cerebrum are called *olfactory lobes*. Where do these lobes seem to lead? What do you think, from the name, their use is?

Just back of the cerebrum, find two large lobes, known as *optic lobes*, which have to do with sight. Look at the chart. Are the eyes connected with the optic lobes? Back of the optic lobe we find the *cerebellum* and *medulla*, the latter running directly into the *spinal cord*, from which rise the spinal nerves you have noted before.

Compare, part by part, the brain of the frog with the model of the brain of man.

Conclusion. — 1. In what respect is the frog's nervous system like that of man? How does it differ?

2. Write a description comparing the nervous system of the frog with your own, using charts and models as a guide.

Problem 223: *To study the structure and use of neurons.*

Method. — Study the figure on page 351, *Civic Biology*. The cell pictured is known as a neuron or a unit of the nervous system. The brain and spinal cord contain many millions of them. One end of a neuron may be in the brain and the other end far away in the spinal cord; or one end may be near the surface of the body and the other end in the spinal cord or brain.

Observations. — How do these cells compare in length with other cells of the body?

NOTE. — If a neuron has for its function the sending of messages from within outwards (to muscles), it is a *motor nerve*. If it receives stimuli from without, it is a *sensory nerve*.

Conclusion. — What structures in the nervous system carry the impulses from the surface to the brain? From the brain to the muscles or other parts of the body?

Problem 224: *What is a reflex action?*

Method and Observations. — If somebody, without warning, pretends to strike you in the face, what happens? Through what parts of the nervous system would you become aware of what was happening?

With your eyes closed touch a hot surface. What happens? Did you think about withdrawing your hand?

Conclusion. — 1. Actions of the sort just described are called *reflexes*. Explain as well as you can, using the figure, the pathway of a reflex action.

2. Does this pathway reach the cerebrum or thinking part of the brain?

Problem 225: *To compare the reaction time of hearing and touch.*

Method and Observations. — Let the class form a large circle and then start a whispered word at one end of the circle. Let the

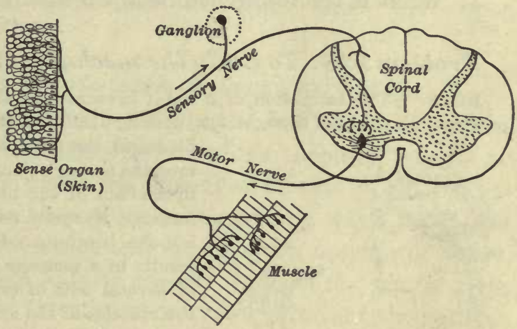
teacher note the number of seconds for the word to get back to the starting point. By dividing this time by the total number of participants the average reaction time for *hearing* of the class can be obtained.

Now let members of the class just touch finger tips. In the same manner as in the previous experiment, let the instructor start a signal (a short pressure of the fingers). Get the average reaction time as in the previous experiment.

Conclusion. — Which gives a quicker reaction, hearing or touch?

***Problem 226:* To compare a reflex action with an act of thought.**

Method. — Using the figures note the pathway with relays of cells between the eye when you see a book, and the rest of the nerves involved when you *determine* to pick it up and *do* so.



AN INVOLUNTARY ACT.

Observations. — Make a diagram showing the pathway. Compare this pathway with the one taken when you touch your hand against a hot stove in the dark.

Conclusion. — What is the chief difference in the nervous pathway between a reflex and an act of thought?

***Problem 227:* To study habit forming.**

NOTE. — A little chick just hatched in an incubator picks at food. It has no mother to teach it. Such an act is called *instinctive*. It is an act accomplished without reasoning. When a new-born baby sucks, its act is also instinctive. Upon such instincts life depends.

Observations. — When a baby is just learning to walk, the first step would probably be brought about by its reaching or stretch-

ing for something it wanted. This would in a way be an instinctive act. Can you explain how?

When you first learned to write, did you think about making the *letters* of the words you wrote? Do you now? How do you account for the ease with which you now write?

What is the chief difference between the *instinctive* act of the baby learning to walk and the *act* of writing? Do we think about writing now? *Did* we think about it when we began to learn? An act *consciously repeated* many times eventually becomes a *habit*. Might a habit be formed through the unconscious repetition of an act?

Conclusion. — 1. What is an instinct?

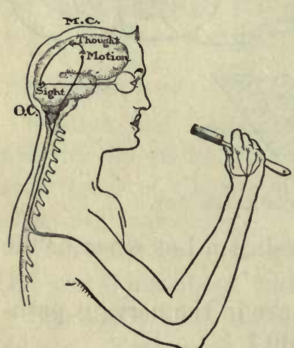
2. What is a habit? How might it be formed?

3. What is the difference between instinct and habit?

Problem 228: To study the mechanism of habit formation.

NOTE. — The formation of a habit involves the simplifying of a complicated process. In an act of thought, *e.g.*, picking up a toothbrush from the washstand (see diagram) the eye sees the brush and relays the message through some sight cells to a nerve center in the back of the brain (*O.C.*). From there the message is again relayed to (*M.C.*), where the impulse is originated to pick the brush up. This results in a message being sent by another relay of several sets of cells down the spinal cord to the muscles of the arm where the fibers from this neuron end in the muscles.

Now if the act becomes habitual, as it does when we brush our teeth each morning, the stimulus caused by the *sight* of the brush causes a short circuit of the impulse which goes to *O.C.* and then directly down the spinal cord.



THE COURSE TAKEN BY THE ACT OF THOUGHT.

O.C., nerve center; *M.C.*, thought center.

Conclusion. — 1. If *M.C.* is the thought center, then what does habit forming do?

2. Would it be better to make a problem of brushing your teeth each morning or to do it automatically (by habit)?

3. Just how is a habit formed in the nervous center?

4. Of what advantage are habits?

***Problem 229**: To consider some harmful habits.*

a. Tobacco

Method. — Allow the smoke from half a dozen cigarettes to pass through the water of a small jar containing a goldfish, or add a small piece of tobacco to the water.

Observations. — What is the result?

Conclusion. — Might tobacco have any similar effect on other living things, as man?

b. Alcohol

Method and Observations. — Using the figures given in your *Civic Biology*, on pages 363, 369, 370, 371, explain why life insurance companies consider moderate drinkers an extra risk.

Conclusion. — What effect does the drink habit have upon man?

***Problem 230**: How to go to work to form good habits.*

Method and Observations. — Study the following statement: "The hell to be endured hereafter, of which theology tells, is no worse than the hell we make for ourselves in this world by habitually fashioning our characters in the wrong way. *Could the young but realize how soon they will become mere bundles of habits, they would give more heed to their conduct while in the plastic state.* We are spinning our own fates, good or evil, and never to be undone. Every smallest stroke of virtue or of vice leaves its never-so-little scar. The drunken Rip Van Winkle, in Jefferson's play, excuses himself for every fresh dereliction by saying, 'I won't count this time.' Well! he may not count it; but it is being counted none the less. *Down among his nerve cells and fibers the molecules are counting it, registering and storing it up to be used against him when the next temptation comes. Nothing we ever do is, in strict scientific literalness, wiped out.* Of course this has its good side as well as its bad one. As we become permanent drunkards by so many separate drinks, so we become saints in the moral, and authorities in the practical and scientific spheres, by so many separate acts and hours of work. *Let no youth have any anxiety about the upshot of his education whatever the line of it may be. If*

he keeps faithfully busy each hour of the working day, he may safely leave the final result to itself. He can with perfect certainty count on waking up some fine morning, to find himself one of the competent ones of his generation, in whatever pursuit he may have singled out." — JAMES, *Psychology*.

Man is thus shown to be a bundle of appetites.

Conclusion. — 1. What are the best ways of forming good habits and continuing to observe them? Write a short composition on this important subject.

2. How should one's judgment and appetite relate to each other?

Problem 231: To determine the relation between taste and smell with reference to food flavors.

Materials. — Vegetables, spices, flavors.

Method. — Close the eyes and hold nose tightly with one hand; with the other place on the tongue pieces of peeled apple, peeled raw potato, peeled raw turnip, and onion. Have the pieces exactly the same taste? Have some one record the results. Are you aware of the different flavors? Are you with the nostrils open? Experiment with a number of other substances, as sugar, vinegar, vanilla, mustard, salt, spices, etc., holding nose and closing eyes.

	Recognized by Taste	Recognized by Smell
Apple		
Onion		
Potato		
Turnip		
Salt		
Sugar		
Mustard		
Vanilla		
Vinegar		

Rub the tongue dry. Place a little sugar on it. In what condition must materials be in order to be tasted?

Observations. — In tabular form note those substances which are learned by taste only and those which are recognized by taste and smell.

Conclusion. — What is the relation of taste and smell in distinguishing flavors?

***Problem 232**: How to find out certain defects of vision in the laboratory.*

Materials. — Schnellen's test cards, spectacles with diopter lenses, clock dial chart.

a. Test for Farsightedness

Method. — Using the Schnellen's test cards, locate the finest line that can be read at a distance of 20 feet. Test each eye separately, covering the eye not in use with a piece of cardboard. Then place a pair of spectacles with a 50 plus diopter lens before the eyes. If as fine or a finer line can now be read, then farsightedness is present and an oculist should be consulted, especially if headaches or other symptoms of eye defects are present. Farsightedness is one of the most frequent causes of eyestrain and is hard to detect because the eyesight seems so good.

b. Test for Nearsightedness

Method. — Use the above-mentioned charts. Determine the finest type you can read at a distance of 20 feet. If it is larger than the 20/20 line, then your vision is defective and you should probably consult an oculist, especially if you have any symptoms of eyestrain.

c. Test for Astigmatism

Method. — Use the clock dial disk at 20 feet. If some lines are blacker than others, then astigmatism is present. If headaches or other symptoms are present, then you should consult an oculist and have glasses fitted to correct this trouble.

Next examine a chart or model of the human eye and determine what defects must occur within your eye to cause the defects in vision you have found. (Your teacher will explain the terms "nearsightedness, farsightedness, and astigmatism.")

Conclusion. — Have I any eye defects? If so, what are they, and how must I go about to correct them?

***Problem 233**: What are some of the effects of alcohol on the nervous system?*

Method. — Using the figures on pages 363, 365, 366, 369, 370, 371, 372, *Civic Biology*, make a graph to show the effect of alcohol upon

memory, mental work, ability to do physical work, efficiency, accidents.

Conclusion. — 1. What effect does alcohol have upon the nervous system?

2. Write a short composition on this subject.

Problem Questions

1. Do you suppose the neurons of a child just learning to walk find it easy to send out exactly the right orders to the muscles? Explain your answer.

2. Do you consciously think about making steps when you now walk? Why not? (Consult chart.)

3. In learning to do anything in concert, how does the first rehearsal compare with the last?

4. What is a necessary factor in forming a habit? Remember that pathways become worn along certain lines so that the neurons in those pathways take up the work instinctively.

5. Explain this story: "A practical joker saw a discharged veteran carrying his dinner home and suddenly called out, 'Attention'; whereupon the veteran instantly brought his hands down, dropping his dinner in the gutter."

6. What is the advantage of forming good habits in life?

7. Does habit forming throw work off part of the nervous system? Explain fully.

8. How are habits formed?

9. Write a paragraph on the increased effectiveness and power acquired through good habits.

10. Is it easy to break a habit? Explain your answer.

11. Why is a grammar school idler quite likely to continue to be an idler in high school, and a high school idler a college idler?

12. Why are the railroads requiring their employees to abstain from liquor?

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XXIV. MAN'S IMPROVEMENT OF HIS ENVIRONMENT

Problems. — *How may we improve our home conditions of living?*

How may we help improve our conditions at school?

How does the city care for the improvement of our environment?

(*a*) *In inspection of buildings, etc.*
(*b*) *In inspection of food supplies.*
(*c*) *In inspection of milk.*
(*d*) *In care of water supplies.*
(*e*) *In disposal of wastes.*
(*f*) *In care of public health.*

Laboratory Suggestions

Home exercise. — How to ventilate my bedroom.

Demonstration. — Effect of use of duster and damp cloth upon bacteria in schoolroom.

Home exercise. — Luncheon dietaries.

Home exercise. — Sanitary map of my own block.

Demonstration. — The bacterial content of milk of various grades and from different sources.

Demonstration. — Bacterial content of distilled water, rain water, tap water, dilute sewage.

Laboratory exercise. — Study of board of health tables to plot curves of mortality from certain diseases during certain times of year.

Note to Teachers. — The exercises which follow are intended to be suggestive and may be extended indefinitely as time may permit. To make this work of most value, as much collateral reading as can well be made available should be used in addition to the definitely planned home and laboratory work outlined in the following chapter. Field work is of especial importance in this connection as it shows the pupils what the city departments are doing toward the inspection of factories, care of food supplies, inspection of milk, both in production and in the sale, provision for a safe and ample water supply, disposal of wastes and care of the public health. An effort should be made to have each pupil procure a copy of the

Sanitary Code of the city in which he lives and then by careful study to see which sections are commonly broken and honored in the breach by the police or health officials. Concerted action on the part of the younger members of a community may bring about decided results for the betterment of a given neighborhood. Thus our biology courses may become, in truth, courses in *civic biology*.

Problem 234: How to ventilate my bedroom. (Home Problem.)

NOTE. — This problem varies, depending on the number and position of the windows in the room. Remember that air without direct draft is what is desired.

Method. — Recall the experiment of the candle and the box with the holes in it. (See problem 214.) What happened when the corks were removed from the two upper holes on one side only? The two lower holes on one side only? The upper and lower holes on one side only? Now apply this principle to the room in which you sleep. Make a diagram to show the air currents in the room when you open the window for ventilation. Is this the best way to have the air currents move? Why?

Where should you place the bed and why? Should you use a screen in your room? If so, where should you place it?

Conclusion. — Make a diagram showing the best way to ventilate your bedroom and give your reasons for thinking this is the best way.

Problem 235: To compare the duster and the dry cloth with the moist cloth in cleaning the schoolroom.

Materials. — Sterile Petri dish with culture medium, broom, oiled rags, oiled sawdust.

Method. — Expose a sterile Petri dish culture in the schoolroom for two minutes while members of the class dust with dry cloths and broom.

The same day have members of the class clean a neighboring room, having the same conditions of dust and dirt, by means of damp cloths and brooms with damp cloths tied or pinned over the part that touches the surface of the floor. Use damp sawdust on the floor. Expose Petri dish as in above test.

Try the experiment in a third room, using oiled rags and oiled sawdust. Expose Petri dish as in test number one.

Place the three Petri dishes in a moderately warm and dark place for three days. Then examine.

Observations. — In which of the three dishes are the most colonies of bacteria and molds? Continue your observations for about one week's time.

Conclusion. — Which of the above methods of dusting a room is the most hygienic and why? (Read Hodge, *Nature Study and Life*, page 476.)

Problem 236: What should I eat for luncheon?

Materials. — Food tables on pages 204 to 209.

Method and Observations. — Eight boys in a class eat the following lunches:

A brings from home two ham sandwiches, a sponge cake, and an orange.

B brings from home two cheese sandwiches and buys a glass of milk and five cents' worth of candy.

C buys a hot roast beef sandwich, a cup of cocoa, and an apple.

D buys a dish of ice cream, one piece of sponge cake, and five cents' worth of candy.

E brings two slices of bread and a square of chocolate and buys a glass of milk.

F buys a Frankfurter, a roll, a small helping of sauerkraut, and a glass of lemonade.

G buys a plate of vegetable soup, a slice of bread and butter, a cup of tea with milk and sugar, and a piece of apple pie.

H buys a helping of beans and a dish of ice cream.

Using the tables on pages 204–209, work out the proportion of carbohydrate, fat, and protein contained in each. Add up the total number of Calories in each. Use any standard you wish, Atwater, Chittenden, or Voit.

In like manner add your own luncheon to the list.

Conclusion. — Which do you think the best balanced? Which the most poorly balanced? Which the cheapest (most nutriment for the least money)? Which the best for a spring or a fall luncheon?

Problem 237: To make a sanitary map of my own environment.

Method and Observations. — 1. Make a large map of your immediate neighborhood by drawing to scale on cardboard, or heavy paper, a map of your home block (if you live in the city) or the neighborhood surrounding your house (if you live in a small town). Locate on the map all the houses by oblong shaded areas and use cross lines to indicate stores. Make an index at the bottom of the map to explain the uses of the different stores or buildings shown. Using board of health signs, indicate any homes in which your local board of health has placarded contagious diseases.

2. Locate on the map any standing water, especially water in old tin cans, gutters, or depressed roofs, sewer openings, catch basins, open barrels, or small ponds in vacant lots. Why should you locate standing water?

3. Find the position of any stables and determine if the heaps of manure are allowed to collect and stand for long periods of time. Why would such manure heaps be a menace to the public health of your neighborhood?

4. Notice the condition of the garbage pails in your neighborhood. Is garbage collected regularly? Are all the pails provided with covers? If not, locate coverless pails. Does garbage ever stand for more than two or three days without collection? Are the garbage pails, after the collection of garbage, washed clean, or is garbage allowed to remain sticking to the sides of the pails from one week to another? What dangers might arise from such pails as the latter?

5. Investigate the condition of all butcher shops, restaurants, or stores where perishable food is exposed for sale. Do you find the shops screened, and the exposed food protected from flies? Are there excessive numbers of flies in the butcher shops? If so, then try to locate their breeding places. Look for bits of stale meat or other refuse that may have been allowed to stand untouched in a given place for over two weeks.

6. Locate any sewer openings or catch basins from which come bad odors. Also locate any outdoor privies, especially if not

connected with the sewer system of the city. If such toilets are not screened from flies, report the matter at once to your board of health. Why are the latter toilets a particular menace to public health? (See *Civic Biology*, page 224.)

7. Locate on your map any pushcarts, stands, or stores in which vegetables or fruit are exposed for sale. Indicate if they are obeying the laws of your sanitary code with reference to the exposure of goods for sale. Why is it a wise law that requires goods exposed for sale to be covered? Is there any spitting in the streets in this locality? Are there any other ways in which germs might get in the dust of the street? How might bacteria be carried from the street surface to the food exposed?

8. Find any public fountains having drinking cups; bubble fountains. Which is more hygienic? Why?

9. Locate any hotels or other places having common roller towels. Why are common towels a danger to public health? What can you do to prevent the use of the public towel in your neighborhood?

10. Locate any other factors that might in your opinion affect public health in your neighborhood. Factories belching forth smoke or acid fumes, tall buildings shutting out light, old tenement houses, and filthy conditions of street are among such factors.

Conclusion. — 1. Is my neighborhood a good one in which to live? Give reasons.

2. How may I help to better the conditions that affect public health in my locality?

***Problem 238**: To determine the bacterial content of different grades of milk.*

Materials. — Different grades of milk, sterile bulb pipette, sterile test tubes, absorbent cotton, sterile Petri dishes containing agar culture media.

Method. — Procure milk from different sources and of different grades if in a large city. Be sure to include milk dipped from a can in some store. Have samples of milk collected kept under identical conditions and be sure that the milk has been collected from the milk companies at the same time. Then treat each

sample according to the following directions: With a sterile bulb pipette draw off 1 c.c. of milk from a well-shaken sample bottle. Add to this 19 c.c. of distilled water, taking care to have the water in a sterile test tube, protected from any dust by an absorbent cotton plug. After mixing the contents of the tube thoroughly, quickly flood the surface of a sterile Petri dish containing agar culture media with the mixture of milk and water. Drain the dish, keeping it covered during the operation; label; fasten down the cover with strips of paper; and place to one side. Treat each of the other samples of milk in the same manner as just described, taking care to label each as to the source of the milk, etc. Place the dishes side by side in a moderately warm place.

Observations. — After two days, and on each successive day for a week, examine the different Petri dishes. Count the number of colonies in each dish. Also note the different kinds of colonies of bacteria present in each of the Petri dishes. Tabulate the results.

Milk	3D	4D	5D	Kinds in each
A				
B				
C				
D				
E				
F				

Conclusion. — 1. Which of the grades of milk examined seems to be most free from bacteria?

2. Should milk be entirely free from bacteria? What do the bacteria present in greatest quantities probably do to the milk?

3. If several kinds of bacteria are present in milk, what can you say of its purity? What ought to be done with such milk before it is used?

Problem 239: *To determine the bacterial content of some kinds of water.*

Materials. — See Problem 238. Omit milk and substitute samples of water.

Method. — By means of a sterile bulb pipette place, in sterile Petri dishes containing agar culture media, equal amounts of

different waters to be tested. Suggested samples are as follows: distilled water, rain water, bottled spring waters of various kinds, city tap water, standing water from lakes or pools near your home, river water thought to contain sewage, dilute sewage. After inoculating the Petri dishes with the water to be tested, place all of the dishes containing the samples in a moderately warm place. Examine after two or three days, and on successive days for one week. Tabulate the results.

Number of Colonies in each

Water	3D	4D	5D	Kinds in each
A				
B				
C				
D				
E				
F				

Observations. — In which Petri dishes does the most bacterial growth take place?

Conclusion. — 1. Which of the examined samples of water are free from bacteria?

2. Which of the samples are best for drinking purposes? Give reasons for your answer.

Problem 240: *To determine some of the problems of water supply and sewage disposal for a city.*

Method. — Visit the sanitation exhibit in a city museum.

Observations. — From information gained from maps in the museum, or in some other way, trace the growth of the water supply of your city since its beginning. Where did the city first get its water? What is now the source of the water supply?

What impurities are commonly found in water? What do reservoirs do to a water supply? State several ways in which a water supply becomes contaminated. How might contaminated waters bounding a city affect the health of the citizens of that city?

How does the sewage of your city affect the waters surrounding it? How is this contamination brought about? What methods are there for sewage disposal? Which would you choose for use in your city? Why? How is sewage now disposed of?

How do conditions of water supply and sewage disposal on a

farm compare with those in a city? How can the unsanitary environment of the farm be made sanitary?

Conclusion. — 1. What steps should a large city take to obtain and protect its water supply?

2. What should be done with the sewage in the city in which you live? Why?

3. What other hygienic steps should a city take to protect its citizens?

Problem 241: Is typhoid a city or a country disease?

Observation. — Make a graph from the following table[1] to show the relative death rate from typhoid in states having a large urban population, and in states having a large rural population.

	Average Per Cent of Rural Population	Average Typhoid Fever Death Rate per 100,000
Five states in which the city population was more than 60 % of the total . .	30	25
Six states in which the city population was between 40 % and 60 %	49	42
Seven states in which the city population was between 30 % and 40 %	67	38
Eight states in which the city population was between 20 % and 30 %	75	46
Twelve states in which the city population was between 10 % and 20 %	87	62
Twelve states or territories in which the city population was less than 10 % . .	95	67

Conclusion. — Is typhoid a city or a country disease? Why is it so? Look up diagram in your textbook.

Problem 242: What is the annual cost to New York city of some preventable diseases?

Materials. — Report of board of health.

Method. — Using the board of health tables for the year 1910, find the number of persons who die from each of the given preventable diseases. Which are particularly children's diseases? Following these directions, compute the annual cost in lives.

[1] Modified from Allen's *Civics and Health.*

	City of New York		City of New York		City of New York		City of New York		City of New York		City of New York	
	Jan. 1911	Jan. 1910	Feb. 1911	Feb. 1910	Mar. 1911	Mar. 1910	Apr. 1911	Apr. 1910	May 1911	May 1910	June 1911	June 1910
Total deaths, all causes	6,961	7,090	6,470	6,270	7,445	7,300	7,185	6,916	6,677	6,323	5,368	5,946
Typhoid Fever . .	27	37	21	27	24	32	20	24	24	23	32	37
Malarial Fever . .	1	1	...	3	6	1	1	3	9	1	...	1
Smallpox	...	...	...	...	...	...	...	2	...	1	...	2
Measles	34	77	57	77	72	129	77	135	116	107	113	85
Scarlet Fever . . .	65	150	85	150	126	159	143	148	131	116	73	83
Whooping Cough .	29	17	31	13	31	17	37	29	40	28	35	25
Diphtheria and Croup	135	202	128	183	149	212	151	221	161	186	90	152
Influenza	152	47	101	49	82	75	50	52	35	24	6	13
Asiatic Cholera . .	...	...	...	...	...	...	...	...	...	...	...	...
Cholera Nostras . .	...	...	...	...	...	...	...	...	...	...	...	...
Other Epidemic Diseases	47	42	52	53	53	61	68	35	71	41	51	38
Tuberculosis, Pulm .	814	767	782	707	824	859	835	809	812	755	678	657
Tub., Meningitis . .	67	76	71	69	84	67	81	64	103	88	95	79
Other Forms of Tuberculosis	46	48	54	42	53	56	51	64	61	53	51	43
Cancer, Malignant Tumor	309	298	275	301	319	330	302	301	323	311	292	304
Simple Meningitis .	53	51	49	52	75	62	44	52	51	58	48	51
Of which Cerebro-Spinal Meningitis	22	26	27	23	25	26	18	30	19	30	15	27
Apoplexy, and Softening of Brain . . .	134	102	94	83	80	94	105	66	63	98	62	74
Organic Heart Diseases	831	679	719	629	738	603	721	576	684	573	528	557
Acute Bronchitis .	98	125	95	92	94	96	97	95	77	57	44	65
Chronic Bronchitis .	41	48	44	39	29	37	28	58	26	37	25	17
Pneumonia (exc. Broncho Pneumonia) .	753	708	632	527	736	736	725	646	456	470	253	307
Broncho Pneumonia	486	624	486	515	640	597	590	538	484	408	298	334
Other Respiratory Diseases	77	84	65	59	87	87	80	96	86	74	48	63
Diseases of the Stomach (Cancer excepted) . . .	45	40	43	45	39	54	35	41	37	46	39	32
Diarrheal Diseases (under 5 years) .	154	150	186	129	274	162	243	210	264	248	272	463
Appendicitis and Typhlitis . . .	48	54	48	48	44	57	61	56	53	43	54	56
Hernia, Intestinal Obstruction . . .	54	46	56	48	46	56	37	44	48	39	40	50
Cirrhosis of Liver .	102	128	91	99	127	89	96	91	101	86	93	93
Bright's Disease and Nephritis . . .	551	529	485	498	558	549	535	498	454	483	342	460
Diseases of Women (not Cancer) . .	26	25	21	29	37	23	36	36	36	41	42	33
Puerperal Septicæmia	28	29	25	31	27	36	26	33	31	20	24	24
Other Puerperal Diseases	40	43	38	46	45	52	38	46	47	47	43	43
Congenital Debility and Malformations	354	392	342	329	357	432	323	366	282	402	271	348
Old Age	71	68	44	60	64	65	54	48	48	74	24	60
Violent Deaths . .	274	326	261	222	417	281	302	299	361	313	324	323
a. Sunstroke . .	...	...	...	...	...	...	...	...	...	...	6	25
b. Other Accidents	249	296	248	203	395	262	284	276	337	293	298	273
c. Homicide . .	25	30	13	19	22	19	18	23	24	20	20	25
Suicide	62	69	50	59	64	66	75	65	74	79	69	92
All Other Causes . .	924	973	913	916	1015	1022	1089	1030	1005	848	879	815
Ill-defined Causes .	29	35	26	41	29	46	29	39	23	45	30	67

	City of New York		City of New York		City of New York		City of New York		City of New York		City of New York	
	July 1911	July 1910	Aug. 1911	Aug. 1910	Sept. 1911	Sept. 1910	Oct. 1911	Oct. 1910	Nov. 1911	Nov. 1910	Dec. 1911	Dec. 1910
Total deaths, all causes	6,648	7,060	6,039	6,052	5,361	5,674	5,495	5,597	5,620	5,566	6,154	6,948
Typhoid Fever . .	56	53	88	58	81	71	63	78	57	66	52	52
Malarial Fever . .	2	3	2	5	5	3	7	3	3	2	2	1
Smallpox	...	...	...	...	...	...	1	...	...	...	2	...
Measles	76	60	41	38	18	28	11	9	10	19	33	21
Scarlet Fever . . .	40	39	11	11	11	16	7	12	15	24	34	45
Whooping Cough .	46	46	49	41	35	21	30	17	8	18	15	22
Diphtheria and Croup	80	116	76	92	49	55	78	76	84	112	100	108
Influenza	2	5	1	3	5	1	10	7	16	14	21	76
Asiatic Cholera . .	...	...	...	...	...	...	...	...	...	...	...	...
Cholera Nostras . .	...	...	...	...	46	36	32	25	24	27	...	...
Other Epidemic Diseases	35	39	43	44	658	674	658	666	673	662	24	26
Tuberculosis, Pulm .	650	728	693	665	...	...	...	...	...	...	711	743
Tub., Meningitis . .	82	77	67	54	58	61	60	58	49	55	46	53
Other Forms of Tuberculosis	50	57	55	48	38	48	32	43	42	37	54	42
Cancer, Malignant Tumor	315	291	345	316	328	319	376	323	337	308	337	308
Simple Meningitis .	35	52	53	41	36	45	39	48	31	36	28	60
Of which Cerebro-Spinal Meningitis	18	23	22	19	19	21	14	25	13	15	9	29
Apoplexy, and Softening of Brain . .	105	66	54	44	62	74	63	89	75	87	108	102
Organic Heart Diseases	596	460	525	391	529	463	629	503	706	608	768	828
Acute Bronchitis .	40	45	32	48	36	60	59	52	87	84	115	109
Chronic Bronchitis .	8	27	15	11	14	14	15	18	22	35	27	66
Pneumonia (exc. Broncho Pneumonia) .	215	199	152	176	165	197	280	309	365	430	543	835
Broncho Pneumonia	251	286	245	241	238	288	288	287	348	332	429	529
Other Respiratory Diseases . . .	60	55	42	47	30	64	48	41	55	65	58	85
Diseases of the Stomach (Cancer excepted) . . .	41	25	35	41	38	40	45	51	38	35	37	51
Diarrheal Diseases (under 5 years) .	807	1632	1034	1175	701	791	408	572	174	231	168	155
Appendicitis and Typhlitis	77	80	69	58	55	39	31	59	41	36	50	53
Hernia, Intestinal Obstruction . . .	47	53	46	58	41	46	31	43	52	44	45	60
Cirrhosis of Liver .	73	74	93	102	95	100	102	76	114	80	100	122
Bright's Disease and Nephritis . . .	379	414	335	412	326	380	363	388	410	469	449	558
Diseases of Women (not Cancer) . .	32	35	24	24	11	22	32	28	29	28	11	27
Puerperal Septicæmia	17	11	25	20	20	13	10	9	17	13	20	16
Other Puerperal Diseases	36	49	43	36	32	37	34	34	36	32	35	41
Congenital Debility and Malformations	314	319	332	360	313	351	318	370	316	292	362	390
Old Age	51	46	24	50	28	39	40	52	29	63	48	58
Violent Deaths . .	939	534	361	331	323	284	293	308	300	310	321	282
a. Sunstroke . .	535	115	17	12	1	9	...	...	...	...	...	...
b. Other Accidents	379	389	322	286	301	253	268	290	270	282	284	263
c. Homicide . .	25	30	22	33	21	22	25	18	30	19	37	19
Suicide	57	85	50	59	43	67	63	64	58	59	72	57
All Other Causes . .	941	886	883	836	804	838	844	807	964	971	921	943
Ill-defined Causes .	93	113	96	116	89	89	95	72	37	24	8	24

Conclusion. — What is the annual cost of typhoid, tuberculosis, and diarrheal diseases of children to the city of New York?

***Problem 243**: What are the chief causes of death in a city?*

Method and Observations. — From the foregoing table determine:

(1) The relation of the number of deaths from infectious diseases to the total death rate.

(2) The diseases which kill the most children.

(3) The per cent who actually die of old age.

Conclusion. — 1. What percentage of all people of the city die from old age?

2. What diseases kill most babies and children under five years of age?

3. What diseases in the list might be influenced by alcohol?

***Problem 244**: To study the relation of the death rate to the season.*

Method. — Study tables carefully in the following manner: Note a given disease, as typhoid, and make a graph, using figures given, to determine the number of cases reported and number of deaths monthly in New York city.

Conclusion. — Is typhoid equally prevalent all the year round? How do you account for its great prevalence in the fall?

(The instructor should divide up the work so that each member of the class will be responsible for a separate graph. A general discussion may then be held on the relation of various diseases to the city death rate. For example: What disease is responsible for the greatest death rate?)

***Problem 245**: To find a relation between flies and mortality.*

Method. —Refer to mortality tables published on pages 270, 271, and fill in the table on the opposite page.

Observations. — With the aid of the given data, construct a graph showing the prevalence of flies and number of deaths per month for the dates given. (In making curves on cross section paper let 1 cm. = 50 deaths, and 1 cm. = 200 flies.)

Conclusion. — 1. Is there any relation between the prevalence of flies and the number of deaths from diarrhea?

Date	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Diarrheals under five												
Average . . . Prevalence of flies	0	0	0	0	0	250	1900	2200	200	400	0	0

2. What factors increase the death of babies during the summer months?

3. How would you fight these unfavorable factors?

***Problem 246**: To determine the number of school children who needed treatment for different diseases in New York city, 1914–1915.*

Method. — Examine the following table carefully. Estimate the percentage of pupils needing attention; the number having defective teeth, vision, hearing, and enlarged tonsils.

Conclusion. — 1. Would any of the difficulties stated in the table interfere with studies? Name and give reason.

2. How would you improve scholarship conditions in the New York city schools?

Physical Examination of School Children, 1914–1915, in New York City

	Total	Percentage
Number of children examined	305,665	100
Defects found:		
Malnutrition	16,340	
Heart troubles	4,121	
Pulmonary disease	502	
Defective vision	25,531	
Defective hearing	1,870	
Obstructed nasal breathing	29,067	
Defective teeth	195,595	
Enlarged tonsils	34,378	
Orthopedic defects	1,729	
Nervous diseases	1,887	
General defects	86,667	

***Problem 247**: How to discover the presence of adenoids.*

Method. — A good medical authority has given the following symptoms as indicating the presence of *adenoids*, growths in the nose and throat which prevent a sufficient air supply from reaching the tissues of the body:

1. Inability to breathe through the nose.
2. A chronically running nose, accompanied by frequent nose-bleeds and a cough to clear the throat.
3. Stuffy speech and delayed learning to talk. 'Common' is pronounced 'cobbéd'; 'nose,' 'doze'; and 'song,' 'sogg.'
4. A narrow upper jaw and irregular crowding of the teeth.
5. Deafness.
6. Nervousness.
7. Inflamed eyes.

Observations. — Observe members of your own family.

Conclusion. — 1. Do any of the family appear to have adenoids? What makes you believe this?

2. What ought people suffering with adenoids to do?

***Problem 248**: To find some ways of preventing the spread of disease.*

NOTE. — Remembering that disease germs must come from the bodies of those who are sick and that such germs are spread usually by means of material from the mouth, food tube, or other openings where germs could escape, our problem becomes threefold. The three parts of the main problem are: first, the destruction of such germs as escape from the bodies of the sick; second, the prevention of such germs as escape from entering the body of well people; and third, the problem of how to make the body safe or *immune* from the attacks of such germs as do get into the body of a well person.

a. How to kill Germs that escape from the Bodies of those who are Sick

Method and Observations. — Using your *Civic Biology* and such other books of reference as you have access to, answer the following questions:

Take some specific disease, as typhoid fever, tuberculosis, or diphtheria. From what part of the body do the disease-causing germs escape?

Having determined this point, next apply what you have learned about disinfectants to the particular disease you are trying to prevent the spread of from one person to another. Remember *contact* with the germ is necessary in order for the well person to take the disease.

In the case of tuberculosis what methods would you advocate for receiving and destroying the material from the mouth (sputum) containing the disease germs?

Conclusion. — How would you destroy the disease germs in a given disease such as tuberculosis, typhoid, or diphtheria?

b. How to prevent the Germs of those Sick from Reaching those in Neighboring Families who are Well. Quarantine

Method and Observations. — Notice the manner in which your local board of health treats families in which infectious disease has come.

NOTE. — This isolation of the patient is called *quarantine*. Quarantine may be done in the home or by removing the sick person to a hospital where only that particular disease is treated.

Why should persons ill with a germ disease be isolated until they are well? What methods have the board of health for warning strangers of the presence of the disease in a home? Why is this necessary? What should be done with heavy rugs, curtains, etc. in the room where one is ill with a germ disease? Why? How could the germs that might lodge in such hangings be killed? Suggest methods. What do we mean by disinfection? Look up your local board of health rules on disinfection and note what is used and how used. (See page 390, *Civic Biology*.) What should be done to the body, clothing, and hair of a person who has been ill with a germ disease before he is allowed to go among well persons again? Why is this necessary? Would a person be selfish who neglected such precautions? Give reasons.

Conclusion. — 1. What is the reason for quarantine and by what should it be followed to be effective?

2. Why is there a quarantine station at the entrance of New York harbor? Why is it of particular value there?

c. How to keep Germs from Entering the Body of a Well Person

Method and Observations. — Notice conditions existing in crowded cities with reference to the number of flies and the relative number of screens over food exposed for sale, etc. Note the condition of the streets and sidewalks, locate saloons or other places where spittoons are found. Find any other places where you think germs might exist and from which they might be carried by flies or other insects. What household insects might be disease carriers? (See *Civic Biology*, pages 225–227.)

Do you find any public drinking fountains? Any common towels? Common combs and brushes?

Also inquire into the condition of your local water supply. Is it pure at the source? Does the supply come from a river? If so, are there any towns or hamlets that empty their sewage into it? What danger might come from this? Is your city doing anything to eliminate this danger? What might your city do to prevent it? What can you do to prevent disease from this source?

What is the condition of your milk supply? Does your board of health do anything to protect the milk supply? If so, then what does it do? Are several grades of milk sold? Is dipped milk sold? If so, for what purposes? How can you protect yourself?

What is the condition of the disposal of sewage in your city? Does the sewage reach a river near by untreated, or is the sewage treated before it escapes? Look up some book of reference in this chapter on sewage disposal, and make a report to the class on some of the methods of sewage disposal. Visit a municipal museum, if possible, and report on various methods of sewage disposal as shown in the sanitation exhibit there.

Conclusion. — Write up a short composition for your notebook, showing all the public and private means that should be taken to prevent germs from entering the body of a well person.

d. How to develop Immunity in the Body of a Well Person

Method and Observations. — Read in your *Civic Biology* and other reference books as to what immunity is and how it is brought about.

NOTE. — Immunity is usually meant when the body develops certain substances in the blood known as *antibodies*. These substances seem to give to the body the power to resist the work of germs that enter it. Natural immunity is only possible when the bodily condition is good.

Of what use to the body in this respect would be good food, rest, sleep, and moderate exercise? Take each factor separately in your discussion.

What might the colorless corpuscles do to help in this gaining of immunity?

NOTE. — Artificial immunity to certain diseases is brought about in the body by the introduction of *antitoxins* into the body. These substances fight the effects of the toxins formed in the body by the bacteria of certain diseases. Diphtheria is one disease so fought. See your local board of health reports for a statement of the preparation and distribution of this antitoxin.

Do you know of any diseases that are fought successfully by antitoxins? (Read *Civic Biology*, pages 390–393.) What great names are connected with the antitoxin treatment of disease? (See *Civic Biology*, pages 391, 402, etc.) How are antitoxins administered? Why in this manner? Look up the subject of vaccination in *Civic Biology*, pages 157 and 391. Who discovered this method of treatment of disease? To what diseases is it applied? Are there any other artificial means of developing immunity in the human body?

Conclusion. — Write a short composition discussing all the ways of developing immunity in the human body.

General Conclusion. — 1. What are the functions of the board of health in any city?

2. How may I coöperate with them in their work for the common welfare?

3. How may I develop immunity?

***Problem 249**: First aid in the home. A summary of what to do and how to do it.*

THE FIRST-AID EMERGENCY MEDICINE CHEST

Every family should have the following materials in the medicine cabinet *out of reach* of young children;

Alcohol, small bottle.

Aromatic spirits of ammonia, rubber stoppered, small bottle.
Carbolated vaseline, small bottle.
Castor oil, large bottle.
Boracic acid, one ounce.
Collodion, in bottle with small brush (use for small cuts).
Chlorate of potash tablets.
Mustard, powdered, two ounces.
Oil of cloves, small bottle (label poison).
Seidlitz powders, small box.
Soda mint tablets, small bottle.
Spirits of camphor, small bottle.
Sirup of ginger, small bottle.
Sirup of ipecac, small bottle.
Subnitrate of bismuth, five-grain tablets, small bottle.
Tincture of iodine, small bottle.

The following articles should also be kept, either in the case or in an emergency kit:

Adhesive tape, small roll.
Absorbent cotton, small package.
Antiseptic gauze, small package.
Clinical thermometer.
Bottle of peroxide or 4 per cent carbolic solution.
Knife, sharp and used for this purpose only.
Scissors.
Paper of pins, safety and common.
Tooth plasters, small package.

The above-mentioned articles ought to be sufficient to make unnecessary the presence of a doctor except in serious cases of illness.

How to use the Materials in the Medicine Chest

Method. — Use any good pamphlets or books on first aid. The small pamphlet known as *First Aid in the Home*, printed and distributed free of charge by the Metropolitan Life Insurance Company, may be used as a text. The uses of most, if not all, of the household remedies are there described.

Try to answer the following practical questions on first aid:

1. What would you do to prevent bleeding from a cut from which blood issued in jets or spurts?
2. What would you do in case of convulsions?
3. How would you treat poisoning in its first stages?
4. If you knew what the substance was that a person had absorbed or taken as a poison, what would you then do? Give three or four different instances, taking common poisons in each case.
5. What would you do in a case of fainting? Drowning?
6. How would you treat a case of sunstroke? Heat exhaustion?
7. What would you do in the case of a burn?
8. How would you treat a bad sprain?
9. How would you go to work to treat a person who has fallen and fractured his arm or leg?
10. How would you treat a cut from a rusty or dirty metal instrument?
11. How would you treat a cold? A case of indigestion? Sick headache? Summer complaint?

Conclusion. — Are you prepared to meet an emergency requiring first aid?

Problem Questions

1. What home conditions do you personally have control over? How would you go about to improve them?
2. What school conditions might you control? What would you do to improve them?
3. What methods of ventilation are best for a schoolroom and why? Illustrate with diagrams.
4. How would you ventilate your bedroom so as to insure fresh air but no draft on the bed? Use a diagram to explain your answer.
5. Why is sunlight important for every bedroom?
6. " We spend one third of our life in our bedroom. Why not have it cozy and well filled with furniture, hangings, and rugs?" Criticize this statement from the hygienic standpoint.
7. Why is a damp cloth the best means of dusting a bedroom?

8. Why, in moving into a new apartment, should the tenant insist on complete renovation?

9. What method of heating is best and why? Explain fully.

10. Give three rules which will help prevent insect pests in an apartment.

11. Why is illuminating gas a dangerous friend at times?

12. Give three good school luncheon menus and tell why they are good.

13. In what respects is factory inspection biological?

14. Why should foods be regularly inspected in a city?

15. How is our city milk supply safeguarded? (See your Sanitary Code.)

16. Show three ways in which a city may protect its water supply.

17. To what extent might a filter attached to a faucet be useful? Why would it not be likely to be effective against germs?

18. Why is typhoid fever considered a country rather than a city disease?

19. What is the work of the department of street cleaning? How can *you* help in this work?

20. What is immunity?

21. What is the theory underlying the practice of vaccination? How does this treatment differ from the antitoxin treatment for diphtheria?

22. What is the method of vaccination for typhoid? Has this method proved of value?

23. How may you coöperate with the department of health in your city?

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